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WILLIAM T. SEDGWICK.
President New England Water Works Association.
1906.

(See page 94.)

REPORT OF THE COMMITTEE ON PRIVATE FIRE SERVICES.

[Presented December 13, 1905.]

Gentlemen of the New England Water Works Association: At the 1902 convention of the American Water Works Association, a report was adopted, expressing the sentiment of the convention that a charge be made for fire protection; that unreasonably large services for fire or other purposes be not permitted; that meters be used where found necessary, and reasonable control secured of all large services.

The Central States Water Works Association, at a convention in 1902, unanimously adopted a resolution expressing the sentiment of the convention in favor of an equitable charge for the protection afforded by private fire services.

At the annual convention of 1903, this Association adopted a report recommending that a charge be made for fire protection; that unreasonably large services be not permitted; that meters be used where found necessary, and all large services provided with a cut-off or a gate so located as, under any ordinary combination of circumstances, to be readily accessible; action along the same lines as that of the American Association for the year previous.

At the 1905 convention of this Association, this committee was enlarged by the addition of Mr. Geo. W. Batchelder and Mr. Hugh McLean, and instructed to consider and report a method or methods by which the value of fire protection can be estimated.

In compliance with instructions, your committee report that fire protection should yield a revenue about in proportion to its cost, as compared with the entire cost of the work; that private fire protection may be estimated at some per cent. of the entire cost of fire protection, and apportioned among those benefited in proportion to the floor space of the protected risks. The cost of fire protection, like that of furnishing water, will vary in different localities, as also the proportion properly chargeable to private fire protection, and this may be determined in and for each individual case. Floor space seems to your committee to be the unit bearing the closest relation to value of the risk and cost of protection, of any readily determined.

We would recommend that charges for fire protection be made on the above basis, with due regard to different conditions obtaining in different places.

Respectfully submitted,

F. H. CRANDALL,
R. J. THOMAS,
GEO. W. BATCHELDER,
ELBERT WHEELER,
Committee.

DISCUSSION.

THE PRESIDENT. You hear the report of the committee; it is now before you for discussion. We should like to hear from Mr. Chase.

MR. JOHN C. CHASE.* Mr. President, I do not know why you should single me out as the first to be called upon, unless it is because I was in such a woeful minority when this subject was threshed out by the original committee. I have seen no reason to change the views that I expressed then, that private fixtures installed by the consumer for additional fire protection should not be subject to an extra charge, as he was already paying for protection under the general tax levy, and his outlay was a benefit rather than a detriment to the water department, the most serious problem confronting them being to prevent the consumer from committing larceny. This view, however, seems to be a dead issue, and from what I have heard of Mr. Crandall's report, I think perhaps the committee have solved the problem in the most practicable manner, and that if a charge for private fire service is to be levied, as the prevailing sentiment seems to indicate it should be, it can be adjusted in no more equitable manner than that which the committee recommends. I think the committee, and also the Association, are to be congratulated upon the apparently successful outcome of their labors, and under the circumstances it is perhaps proper that I should be the one to now move that the report be accepted and its recommendations adopted. I do not know that I have anything further to say in relation to the matter, except to thank you for giving me the prominence of being the first one to be called upon, with a clear field and no chance of any one else having said what I wanted to say.

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* Derry, N. H.

THE PRESIDENT. We are all very sorry that a man who was as much interested in this subject as any man in Boston, Mr. Edward Atkinson, has passed away since we last met. I will call upon Mr. French to speak.

MR. EDWARD V. FRENCH. Mr. President, I did not expect to be called on in this way. I do not know that there is much that I, or perhaps any one of us, can say with regard to Mr. Atkinson. We all knew him, we all have seen him here on a good many occasions and have been interested in what he has said, and we were always pleased with the vigor and constantly continuing interest which he had in all these subjects.

Mr. Atkinson came down town on Monday in the usual way, but on reaching the office it was found that he was not able to get out of his carriage. Although every effort was made to give him help immediately, he died an hour or two afterwards, just after reaching the hospital. Mr. Atkinson was about seventy-nine years of age, and, as we all know, lived a most vigorous and energetic life, always working, always busy, always having many interests. I think it is an inspiration to come in contact with a man, whether we agree with what he thinks and with what he does or not, who is so thoroughly alive, and especially at Mr. Atkinson's age, towards all the important problems of the day.

THE PRESIDENT. Mr. Hammond.

MR. J. C. HAMMOND, JR.* Mr. President, I am glad that the mantle of Elijah has fallen on so good shoulders. We certainly have a very able Elisha in the insurance host.

I came here some years ago trying to find out what was a fair charge for fire service, in view of the greatly increased cost for mains over and above the necessary cost for domestic supply alone. I simply asked what would be a fair charge for the fire service, and I was so thoroughly convinced (?) by the arguments I heard from the insurance people that we couldn't charge anything, that I went home and said to our livery man, " Send the team over to the office every morning; if we use it we will pay for it, if we don't, we won't." [Laughter.]

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* Treasurer, Water Company, Rockville, Conn.

THE PRESIDENT. I should like to call upon Mr. French.

MR. FRENCH. Mr. President, again I am hardly ready to say very much. I think Mr. Hammond's story is too good to try to spoil any of the influence of it right away. It is some little time since we have given this question of charging for water very much attention. In the last few years our efforts have been mainly directed toward preventing the improper use of water. I felt after the experience on the previous committee that if we could put the fire service into such condition that it would be properly used, a good deal of our present difficulty and the feeling of suspicion about it would disappear.

Now this question of charging for fire service is a difficult one. It brings up all the general questions of methods of taxation, and in trying to go into it, and in working a considerable time on it in connection with the committee, when Mr. Hammond and I were together, I found it extremely difficult to find any very satisfactory method of charging. To go back a bit, I have not really had an opportunity to consider exactly how this report would work out, but I should think it would be better than the method of charging so much per sprinkler or so much per hydrant, which has the effect of making a man very reluctant to add a sprinkler here or there in places where sprinklers are needed.

One other point is that in the case of almost all other commodities we pay for what we get; and I tried to work out some sort of a plan by which a man would pay so much per fire stream available at his yard as serviceable pressure. Now on the basis just proposed, if in a city or town there were two plants of the same floor area and about the same value, and one of them was in one end of the city, perhaps near the reservoir, the owner might be able to draw eight fire streams from a connection, which we would all be willing he should have, into his yard. The other manufacturer, at the other end of the town, but just as much within the limits of the town, perhaps no further from the city hall, might not be able to get more than three or four streams, on account of the fact that he was farther away from the reservoir. Now, by this method of charging, you charge both men the same, while one man would be getting twice as much as the other.

Of course, I realize that all these things are matters of compromise, that we have got to strike on some workable scheme, but it isn't exactly fair to charge on that basis, when a man doesn't get what he pays for, so to speak. Perhaps there is no better way to do it and I am not ready to criticise, but simply want to bring out all sides of the question.

Another point: it is true that the man who puts in private protection does get a saving in the cost of insurance. He gets it by spending usually from three to five per cent. of the value of his property, in putting in automatic sprinklers, fire pumps and hydrants. Now that man, if he hadn't put in that private equipment, would clearly have been entitled to the use of the entire fire department of the city. If his plant had gotten on fire, no man would have thought of charging him anything for the services of the fire department. I know I have said this before, but it may be well to repeat it. If he puts in his private fire protection the chance of his having a fire which will necessitate his calling upon the public department is very small. Our experience shows that in 90 per cent. of the cases the opening of five or ten sprinklers puts out the fire. Those fires, had they been allowed to go on for any length of time, would undoubtedly in many cases have become larger.

Going further, the risk, if unprotected, may be a serious menace to surrounding property. I think nobody questions that if the building in which the Baltimore fire started had been sprinklered it would not have burned as it did, and the Baltimore conflagration would not have occurred. If the owner or occupant of that building had put in automatic sprinklers at his own expense, he would have saved the community an enormous amount of money. And the one point that I want to make clear is that there is a very distinct gain to the community from private protection. There is a gain to the owner, nobody denies that, but there is also a very distinct gain to the community; and, perhaps, if we look at it in all its lights, we will realize that it may be the highest type of public policy to encourage private fire protection.

I should say that if the water for fire protection of a city were paid for by the general tax levy, as is true in some cases, — while in other cases it is paid for simply from the water department's funds, — it would seem that any taxpayer had the same right over it that any other taxpayer had, and that the better facilities he provided at his own expense to use the public water which is there for this purpose, why, really, the more he was doing for the common good. I hope then that we will not lose sight of the fact that a great advance is being made in cutting down the annual fire loss in this country, amounting to $150 000 000 on the average for ten years past, — or, if not cutting it down, at least in preventing it growing larger as our country grows, — by the use of private fire protection. This certainly is the case, and it ought to be a factor in any action taken by public servants looking at it from the point of good citizenship.

MR. CHARLES W. SHERMAN.* Mr. President, if the force of all Mr. French's arguments is granted, and they certainly have a great deal of force, the fact nevertheless remains that at the present time the cost of fire protection furnished by a private water company is not at all borne by the municipality, excepting in so far as it pays hydrant rental, and in that way, as a rule, no portion of the cost of private fire protection is covered. This question was first raised, at least in this association, in connection with private companies, and perhaps its most important bearing at the present time is to furnish a basis for private companies to make such a charge, more so than in the case of municipally owned plants; and in that direction especially the report of the committee, it seems to me, is going to be of great value. I think Mr. French will concede the desirability of something of that sort in connection with private companies, even though his principle that in equity such a charge ought to be borne by the municipality should stand.

MR. CHARLES K. WALKER.† The other day a man said that he wanted fire protection for a barn, which they use for storing cars in; their car barn had burnt up. They wanted to know what I would do about it. I told them I wouldn't do anything about it if I could have my say, but I can't have my say.

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* Civil Engineer, Boston, Mass.

† Superintendent of Water Works, Manchester, N. H.

Now they wanted a pipe put into this car barn. They wanted a 6-inch pipe on one end — it is about 200 feet long — and they wanted a 6-inch pipe on the other end. And then, by the way, they wanted a pipe to another car barn on the opposite side of the street. They wanted a 14-inch pipe tapped and two 6-inch pipes on one side and one 6-inch pipe on the other side; and there was no other way to do than as the commissioners told me, and the commissioners did just what the insurance underwriters told them to do. The result was that we put those pipes in. I objected to it. We don't get a cent out of it. Perhaps they will pay for the connection, but they won't pay anything for supplying water to these places. I say it is all wrong. I say that these insurance folks ask too much. I think we ought to have compensation for furnishing water to these places; a small amount, perhaps, but we ought to have something for keeping up these supplies: and I think it is the duty of every city to charge for the supply of these places with water in case of fire.

MR. HAMMOND. Right in that line, Mr. President, I would say that we have two 8-inch and one 6-inch connection on a 10-inch main, as fire protection for a manufacturing plant. Abraham Lincoln used to tell of a steamboat on the Mississippi with a 100 horse-power engine and a 200 horse-power whistle, and every time they blew the whistle the boat stopped. Now, I don't think it is good policy, if you have other property on the line, to jeopardize the whole thing for any one concern. A man who makes tanks out West sends out his circulars and tells his customers that if they will *buy* a tank and put in sprinklers he will guarantee that they will get the cost back in five years in the saving in insurance. Now, I think there are two sides to this question. The insurance people shouldn't come in here and say that we should furnish free water, while at the same time they say to the manufacturers, "Our companies will only charge you a quarter of one per cent. for insurance with sprinklers, which you couldn't get in the stock companies short of 2½" Am I not right? Still they say that there should be no charge for water if the insured don't use it. It is there for them to use if they want to use it, and when they pay for their insurance they pay the low rate because it is there.

MR. FRANK C. KIMBALL.* I remember attending a convention of this association in September, 1902, when I believe there were three reports made on this subject. It appeared very conclusively at that meeting and by those reports that the water-works superintendents and the underwriters couldn't lie down in the same bed together.

As a result of that meeting the Private Fire Protection Committee, which has reported to-day, was appointed. Whether it has been due to the work of that committee, or to an increased sentiment along these lines, or to some other good reason, I am very glad to note to-day that Mr. Crandall again reports for that committee, stating among other things that fire protection should be paid for, and Mr. French now gets up and says: "Pay for what you get." In other words, he agrees with Mr. Crandall to-day, whereas he didn't three years ago, under the principle, as he states it, "Pay for what you get." Nobody who gets fire protection would for a moment say that he is not getting something.

I was very glad also to note last September that, while that portion of the committee of 1902, of which Mr. French was a member, reported against metering fire connections, Mr. French himself gave us a very good illustration of how a person can be converted at times and also showed us the results of his conversion in a meter which I for one am free to say comes very close to filling the bill; if it is not exactly what the water-works men themselves are after it is so near it that a company I am interested in is going to try one of them and see how it works, and I think before we get through we shall try several.

It seems to me that this question now has got beyond any discussion. The underwriters agree that protection from petty larceny or grand larceny is necessary for the water companies or water departments. They also agree that something should be paid. That is as far, I think, as we can ask them to go. And I think that they will agree with me when I say that it is not within their province to say what that something shall be. Mr. French says, " Pay for what you get," and that a price which would be adequate in certain parts of a town might not be adequate in another part. Unfortunately you can pick flaws in any schedule or plan for anything that may be offered. It may also be unfortunate for them, although perhaps fortunate for the public, that water-works superintendents and departments are to some extent controlled by the courts, which say that you shall not discriminate. They do not look at these points quite so finely as the underwriters do, and when you charge a man in one part of the town one price and charge a man in another part of the town another price, they say that is discrimination.

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* Civil Engineer, Boston, Mass.

I have perhaps given this question of charges for fire protection as much consideration as the average member here, and in going over the possible methods of charging for protection, the one that seems to me to be open to the least objection is that of charging by floor space. Floor space bears some relation to the value of the property,— the larger its area the more valuable. It also bears a distinct relation to the space to be protected; the larger area means, to some considerable extent, larger pipes. Now, you can reason this thing in a complete circle. Fire protection should be paid for. When you pay for fire protection you should get what you pay for. In that way, paying for fire protection you have a right to ask for that protection. You are obliged to put into your works larger pipes, larger pumps, etc., and, as Mr. French said a few moments ago, while in your general tax levy the hydrants along the public streets are paid for, I think he will say that hydrants every 300, 400, or 500 feet, as they usually are along the public streets, are not adequate protection to his mills, thoroughly equipped with sprinklers and yard hydrants, where in a space of 500 feet, perhaps, he would require 6, 8, or 10 yard hydrants and innumerable sprinklers. I don't blame him; I would if I were in his place, and it may be it is necessary for the proper protection of the property. But mains which will adequately supply hydrants placed every 300, 400, or 500 feet apart, are not adequate, nor will the underwriters accept, with their minimum insurance rates, the same sized mains for the protection of their mills, supplied as above. The result is that if you are going to furnish such mill owners with *proper* protection, the first thing the water department has to do is to reinforce its mains, either by running a larger pipe along the street or bringing in connecting pipes across and around from other directions. So I think the argument that private fire protection costs nothing, or that it only costs what public fire protection does, was settled — it certainly was in my mind — long ago.

MR. FRENCH. Mr. President, if I may take a minute more, I just want to set myself right on one or two points. In regard to what Mr. Hammond says, I think it wasn't quite fair for him to suggest that I came here saying that there should be no charge made. I said nothing of the kind. And in regard to what Mr. Kimball said, I would make a slight correction, for neither did I say that I was ready to agree that charges should be made in all cases. I simply said that I hadn't considered the matter for some little time in detail, and I only tried to bring out a few additional points.

I realize that it is a complicated question. I realize that in some ways it is a question about which we should say nothing, perhaps; but I think we can at least properly bring out some points on the other side, for it is always fair to show up both sides of a question. In the main my argument would be that whatever charge is made, if any is made, should be equitable. You shouldn't single out the few men whom you can most easily find and charge them for fire protection because they have spent their own money for apparatus so as to be better able to use the public water service, while you do not charge other people, who have the same service standing ready for them, like Mr. Hammond's hack at the door, ready for them to use whenever they want it. You certainly should not charge them. I will put it in this way, more than you charge other men who simply depend on what the city may furnish them.

Now I should like to throw out one other thought. Take it in Mr. Hammond's excellently protected town; I should like to know who pays for the water and who pays for the service which is rendered to the unprotected property? If some night an unprotected building takes fire and the public fire department throws twelve streams for five hours, the owner certainly has the use of the public service and the use of a good deal of water; but I haven't heard anybody say much about who should pay for that. When the water works are owned by a private company, we all agree that the company should be paid in some way. When the supply is merely a department of the city, having its own books and its own accounts and no other money, then it is perhaps entirely proper that from some source, say the general tax levy, or from the fire department appropriation, or from somewhere, it should get some return for the somewhat larger pipes, perhaps larger pumps and larger reservoir. I think we would all agree that fire service increases the cost of the public water works in many places, especially in the smaller ones. Now somebody ought to pay for that, but not simply the few men whom we are singling out to-day.

I would like to leave the matter in this way: That my own mind is open. The companies with which I am connected certainly do not want to ask anything unreasonable. I do not come here with any such intention. We would merely like to present these other points to show that the question is not a perfectly simple one, and to urge that whatever is done shall be done on an equitable basis and with due regard to all the factors in the case, and with proper encouragement of things which are a real benefit to the community. With more time for thought, we might have something more definite to suggest, but that is our position to-day. It is simply a plea for fairness and a plea for a broad view of the whole situation.

MR. HAMMOND. It is said that early impressions are lasting. Perhaps my words didn't convey my idea, but I think the insurance men have been coming up here for about three years. In the early stages of this discussion, as I understood from Mr. Atkinson, a gentleman whom we all revered, these manufacturing concerns were a part and parcel of us, we were dependent upon them entirely, and we should protect them without any charge. Now, in my town, our manufacturers do not ask for that. What started this thing with me three years ago was to see how we could get at a fair charge, and I advocated then, as I advocate now, that it should be on the basis of the amount of insurance. We have a concern which makes envelopes, where several thousand feet of floor space is occupied by paper boxes, while in another establishment, where they manufacture silk, almost all the floor space is occupied by valuable machinery. It isn't fair to tax them according to floor space, but it seems to me it is fair to charge them according to the amount of insurance carried, for the saving in insurance is something wonderful. One of the most beneficent things of the age is the development of fire protection appliances. Fires occur now which we don't know anything about until they are extinguished, and it is a grand thing; but the people who furnish the water should have some compensation, and the manufacturers in our place are willing to pay it. The simple question is, What is a fair basis to put it on? Now, what is fairer than to say that if one concern carries $100 000 insurance it shall be a certain percentage on that, while another concern, having more valuable machinery and carrying $500 000 insurance should pay on that basis? It isn't a question of our robbing them or of their robbing us. That question hasn't been raised. But when we ask what is a fair basis to put it on, we don't like to be told that they shouldn't pay anything.

MR. HORACE G. HOLDEN.* At our New York meeting, last September, I made inquiries among the members to find out if there was any place where they made any charge for fire service, and from what I could learn there wasn't a place in New England where any charge is made. I talked with several of our western members and found that through the West in many places they did make a charge, and I have had some correspondence since in regard to the charges. Perhaps it will be interesting if I read to you what their charges are. This is from the office of the Louisville Water Company, Louisville, Ky., which is partly a private and partly a public company — I think the city owns some of the stock.

" At a meeting of the Board of Directors of the Louisville Water Company, held December 23, 1898, the following amended rules and rates for fire protection service water pipes were adopted, viz.:

" ' 1. That the water company locate and place all special private service connections for fire protection and automatic sprinkling devices from street mains to the property line of property owners and maintain same at the cost of the company.

" ' 2. That the annual rates for such special private fire service connections, payable semi-annually, subject to the usual discounts for prompt payment to water consumers, shall be as follows, to wit:

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* Superintendent of Water Works, Nashua, N. H.

1-inch connections	$6.00
1¼-inch connections	8.00
1½-inch connections	10.00
2-inch connections	15.00
3-inch connections	20.00
4-inch connections	30.00
6-inch connections	50.00

" ' If the above rates be not paid under the rules and regulations of the company governing water consumers generally, the water supply is to be discontinued until payment is made.

" ' 3. Where larger private special fire service connections (above six inches) are desired, the rates and conditions applicable thereto shall be determined by the water company, having due reference to the size of street mains, locality and surroundings, the cost necessary to the company in the premises, and the current expense of maintenance.

" ' 4. Such property owners now having such special private fire protection or automatic sprinkler service connections, and have paid the water company the first or original cost of installation, the same to be refunded by the company.' "

Here is a resolution of the Cleveland, Ohio, Board of Public Service, passed July 28, 1905:

" ' *Whereas,* the water department is subjected to considerable expense in the inspection of fire lines, and

" ' *Whereas,* the street mains have to be made larger than otherwise to keep up the pressure in adjoining buildings when a large tap for fire purposes is installed, and

" ' *Whereas,* the department makes no charge for the use of water for fire purposes, therefore be it

" '*Resolved,* that beginning July 1, the following charges be made every six months for fire service, and shall be payable in advance like other water charges:

Size of Tap.	Semi-annual Charge.
1½-inch	$5.00
2-inch	7.00
3-inch	10.00
4-inch	12.50
Two 4-inch	20.00
6-inch	25.00

"'No charge, however, shall be made where the fire line is metered at the expense of the owner except the semi-annual payment of $4.00 hitherto required for all meters over ¾-inch.

"'The first payments shall be made July 1, for the three months July - September 30, pro rata, and thereafter October 1 and April 1, for six months as above.

"'*Resolved*, further, that on all fire lines the owner of the property shall deposit with the water department a full drawing or plan of said fire lines satisfactory to the department within sixty days from date. Drawings of all new fire lines or changes in old ones shall likewise be deposited with the water department within sixty days after said new lines or changes have been installed. No alterations in fire lines shall be made without permission in writing in advance by the water department. Drip cocks or valves intended to drain the fire lines shall not exceed ⅛-inch inside diameter, unless with the consent in writing of the superintendent of the water department, and must be placed at the lowest point on the lines. The connection shall not be turned on or off, save by the city water department, or with the consent of the superintendent of said water department. Failure to conform to this resolution shall be followed by shutting off the water from the fire lines of the party concerned.'"

That seems to be the way these two companies, one a private company and the other a public department, make their charges for fire service. I don't know whether the people in our New England cities would stand that or not.

MR. CHARLES N. TAYLOR.* Perhaps I might add a little information along this line. I was called upon not long ago to act as a committee of one to fix the amount to be charged a woolen mill for fire protection. I built the works two years ago, and the parties who owned the mill were large stockholders in the water works. They had not paid anything for fire protection, and the smaller stockholders naturally began to object. They had gotten a large reduction in the cost of their insurance on account of having the water, and they finally proposed, perhaps very unwisely, to leave it to me to say, as a disinterested party, how much should be paid. In order to act intelligently, I wrote to a good many different people, private and municipal companies, and finally I made the recommendation, which has since been adopted, something as follows: that they pay so much per sprinkler head and so much per hydrant. These prices, as I remember them, are $30 per hydrant per year, and 25 cents per sprinkler head per year up to 1 000 sprinkler heads. Beyond that the price is reduced, as I remember it, to 15 cents, and the whole amount is computed on that basis. This seemed to be satisfactory after they thought it over and figured it up, and I believe it was acknowledged that, though they thought the price was high, they were saving considerably more than that in what it cost them for insurance.

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* Civil Engineer, Wellesley, Mass.

In another place I have been obliged to deal with pulp mills of the International Pulp Company. The mains at Orono pass the mills, and we were several months deciding on what would be a fair price. They conceded that they wanted the water, they needed it, and we had no doubt that we wanted to sell it to them. I finally said for the company that they could have the water for $150 a year for their pulp plant, but this they said was more than they could afford to pay. As time went on, however, I presume the insurance people assisted me somewhat in getting them to come to my terms, for they finally said, All right. Another pulp mill in the same town pays us $350 a year for water for fire protection. For other purposes they pay the regular rates.

In the town of Strong, Me., is located a little toothpick mill, which, by the way, is the largest toothpick mill in the country, and that isn't saying very much, and they pay $300 a year for water for fire protection and for use for their boiler. These instances are all I have in mind, but they are actual amounts which are paid in different places and may be of some assistance.

Mr. R. C. P. Coggeshall. I should like to see Mr. French's meter tried somewhere on one of these large supplies, for I have an impression that if it works as it bids fair to work, the revenue from the aggregate of the small leaks inside of one of these large enclosures where they have pipes by the mile, would, in the course of the year, be a considerable amount, and perhaps we wouldn't need to get paid for any more than what the meter registers.

Mr. George H. Snell.* I haven't heard the entire discussion, Mr. President, but I have been interested in this subject for a number of years, and I think it is one which should be fully discussed before we decide to make a charge. The gentleman who was speaking as I came in made a remark about how many fires were put out which we didn't know anything about until afterwards. If it is a private water company, of course they are saving money, or if the works are owned by the town or city they are saving money, by having those fires put out with a few gallons of water, whereas if they hadn't been thus put out, it might have taken several million gallons of water. It is very hard to draw the line as to what we should do in the matter. If a town can afford fire protection to the people, wouldn't they be better off to furnish it and take the chances, and let them have the benefit of the low rate of insurance, rather than to charge them and run the risk that they will go to some other town where protection would be furnished for nothing? That is another thing to be considered.

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* Superintendent of Water Works, Attleboro, Mass.

I should say that if there was some way so that we could be sure that the water was not being wasted or misused in these buildings, if we could get to the point where we were sure the water wasn't being used for any other purpose than for fire, and the leaks were taken care of, I believe that would be the best solution of the question. The only fault I find on my works is with their opening the hydrants. They do it because they have a Stilson wrench, and they want to wet down ashes or something, and they use the water because they get in the habit of it. They don't do it by orders from the firm or the owners. If the hydrants are sealed, as I believe Mr. Coggeshall has all of his in New Bedford, and then we have some penalty for breaking the seal, I think that would remedy a part of the trouble, and thereby eliminate the misuse of water in this way.

Mr. Frank L. Fuller.* In our town we charge $10 for each private hydrant. There are not many of them, but those who have to pay the bills haven't made much opposition. It has always seemed to me that it wasn't more than fair or right to make some such charge. Our system has cost a good deal of money, largely because it has been built sufficiently large to provide this very fire protection which these people demand, and, therefore, it has always seemed to me no more than fair that there should be some reasonable charge for private hydrants.

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* Civil Engineer, Boston, and member of Water Board, Wellesley, Mass.

MR. SNELL. There is just one point more that I should like to mention. About two years ago we decided that we would lay all underground pipe, and set all private fire hydrants at the expense of the owners, so as to have it uniform with our own system, and in order to protect ourselves from leaks. I think that is something which every water department should look into carefully, for the work done by contract is sometimes not acceptable to the town, and it costs the town nearly as much to inspect the work as to do it themselves in some cases,— so we have found, at least. We do all the outside work which is done for private fire protection, and we find this to be a great benefit to the department.

(Mr. Chase's motion was put and adopted.)

ELECTROLYSIS.

TOPICAL DISCUSSION.

[December 13, 1905.]

MR. EDWIN C. BROOKS.* I have been requested to open the discussion on the subject of " Electrolysis," as we have had considerable trouble in Cambridge from electrolytic action. Two years ago our 40-inch steel main was very badly affected; we dug up about 800 feet in length of it and made some extensive repairs. We have since had several leaks in the immediate vicinity of the car barns on Boylston Street, close to the power house. Notwithstanding that the 6-inch pipe that you see before you (Plate I, Figs. 1 and 2) was alongside of the Metropolitan 48-inch pipe, you can see the destructive action which has gone on there. And I should like to call the attention of the members to this fact, that that pipe has been in the shop for just about a year, and when it was taken out of the ground and wiped off, only those places that are eaten out showed on the surface. The other part of the pipe looked like any ordinary pipe. But as it dried out, and as the rusting took place between the graphite — if that is a proper term to use — and the iron, it forced off the pieces that are formed in those cavities, and you will notice, if you examine it, that that action is going on all over it at the present time.

I have here a sample that came off from the pipe, and it shows very plainly the action which takes place, viz., that a little rust begins to form upon the clear iron at the bottom of the graphite, and as it forms it forces this piece out, and, as I say, I think you will see that action going on there in the pipe.

I was very much struck, on seeing photographs of some water pipes in Dayton, Ohio, and, I think, in Providence, R. I., by the apparently immense holes in the pipe, and I could not conceive how it was possible that those holes could have been so large when the pipe was taken up. You will see, however, that the destructive action goes on until there is a mere shell of iron between the inside of the pipe and the bottom of this substance

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* Superintendent of Water Works, Cambridge, Mass.

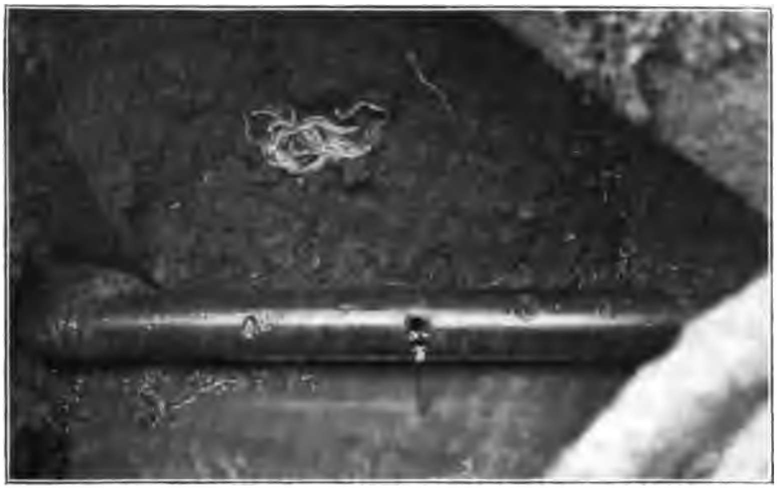

FIG. 1. ELECTROLYSIS OF 6-INCH WATER PIPE IN CAMBRIDGE, DECEMBER 13, 1904.

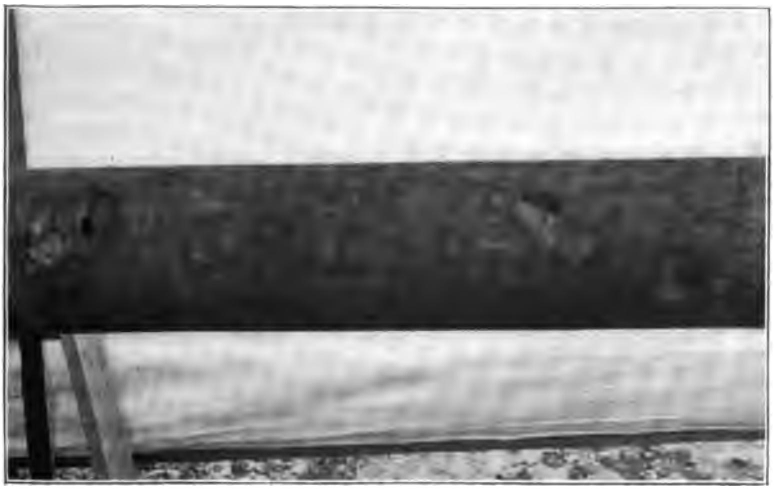

FIG. 2. SAME PIPE AS IN FIG. 1, AFTER EXPOSURE TO THE AIR FOR A YEAR.

that the electricity forms, and that when the pipe gives out it gives out over a considerable area, making quite a large hole.

You will see near one end of this pipe which is before you two holes, and they were the cause of our taking it out. Those two holes came at one time, and it took a plug an inch or more in diameter to plug each one of them. I think that very satisfactorily explains the appearance of these pipes that have been taken out in various places, and which look so badly.

Now; as I say, that pipe was close to the Metropolitan 48-inch main. It was crossed by a lot of car tracks going into the stables of the Elevated Road on Boylston Street. You can see that, notwithstanding its close proximity to that 48-inch pipe, it still was carrying quite an amount of current.

We have considerable trouble with supply pipes in certain sections; and we have had pipes give out under the telephone conduits as well as under the railroad conduits. It does not seem that we are immune from trouble even from the telephone conduits.

I have here some photographs * showing the condition of our 40-inch steel main as it was found two years ago, and also the method of repairing it. During the past year we have had no trouble from our 40-inch main. It has been connected with the rails at one point, and we have put in insulating joints at other places where the current was liable to go on to the pipe. We use the joint that the Metropolitan engineers have devised, that is, a flanged joint with a thick rubber gasket between, and rubber insulation on the bolts by which the flanges are bolted together, and also under the heads and nuts of the bolts.

I have been merely called upon to start the ball rolling here, and I would like to have you gentlemen who are interested in the subject look that pipe over and see if you don't think that it would be very easy, on a casual inspection of the pipe in the trench, to decide that there was no electrolytic action at all; whereas, if you took the care to examine it carefully with a pick or sharp point of any kind, you would find plenty of soft places that you could dig out. I hope, Mr. President, that you will call upon our friend, Mr. Foss, to give us a little talk on this subject, for he has looked into the theoretical part of it, and is very well

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* Not reproduced. — ED.

acquainted with the trouble we have had and also with the trouble that has been experienced generally in Boston and vicinity.

THE PRESIDENT. We should all like to hear from Mr. Foss.

MR. WM. E. FOSS.* Mr. President and gentlemen, these specimens that Mr. Brooks has thoughtfully brought here for our inspection direct our attention to the difficulty of detecting injury to cast-iron pipes from electrolysis, by a visual inspection only. It is usually easy to see the effects of electrolysis on a lead, steel, or wrought-iron pipe from a rather careless examination, but the injury is found on the cast-iron pipes only by a very careful examination with a testing hammer or a knife. If the pipe is of lead, steel, or wrought iron, the metal is usually completely eaten away, leaving a visible pit or hole, but if of cast iron, the iron is removed without destroying the form of the pipe which remains perfect, although the remaining substance is a soft material, like carbon, which can be easily cut with a knife or chipped with a testing hammer.

A while ago, I had occasion to examine a 48-inch pipe line for electrolytic injury, and was unexpectedly detained at the office until after the workmen had completed the excavation. As I did not appear at the appointed time, the foreman examined the pipe, and telephoned to me, reporting that he had looked the pipe over very carefully and found it as good as new, with no evidence of any injury. He was directed to keep the excavation open, and when a careful inspection of the pipe was made with a testing hammer, a large number of deep pits were found in it.

An interesting feature in connection with electrolysis is that no way has yet been discovered to entirely prevent the action where the single trolley electric railway is in operation, although investigations of the process have been made during the past ten or fifteen years.

Fairly good results have been obtained by bonding telephone cable sheaths to the rails or return wires, to protect them. A complete knowledge of the electrical conditions existing at the time the bonds are connected is necessary in order to properly locate them, and continual inspections are necessary after they are connected, to detect the continually occurring changes in electrical

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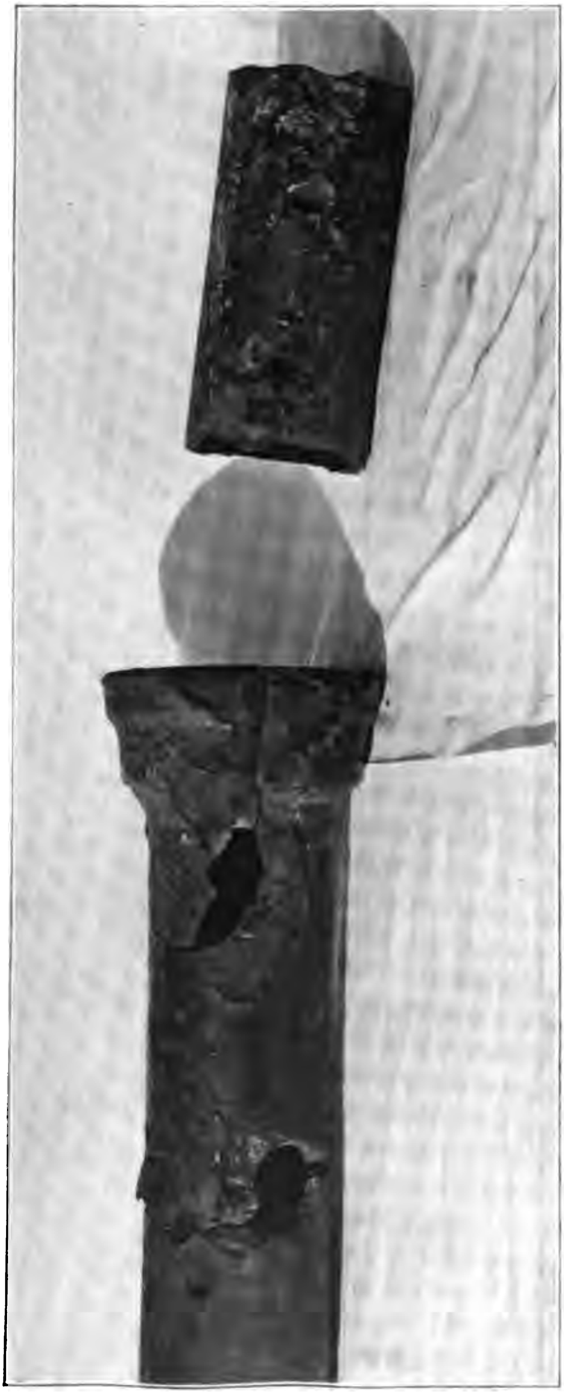
* Division Engineer, Metropolitan Water Works, Boston, Mass.

PLATE II.



6-INCH HYDRANT PIPE UNDER TELEPHONE CABLE, DESTROYED BY ELECTROLYSIS, CHELSEA, MASS.

conditions as soon as they take place, so that the necessary relocation of the bonds may be made. An objection to this method of protection is that it causes increased action on the other structures buried near the cables. An example of the damages caused in this way is given in the photograph, Plate II, which shows a 6-inch hydrant pipe which burst while the hydrant was in use during the fire which destroyed the Academy of Music in Chelsea, on January 11, 1905. This break was due to the disintegration of the iron by electrolysis at the point where it crossed under a telephone cable which had been bonded to the railway return for protection.

After bonding, the cable is actually a portion of the street railway return system, and, on account of being buried several feet below the surface in the damp ground near other structures, is more likely to cause electrolysis than a rail located on the surface. As much as 500 to 700 amperes is drained from the cables over some of the bonds.

Attempts have been made in a few places to protect the water and gas pipes from electrolysis by bonding them to the rails, but the results have not been entirely satisfactory. In two cities where the pipes were bonded to the rails about ten years ago, the pipes have remained positive to the rails in some districts, the injury to service pipes has continued, and it has recently been necessary to employ experts to investigate the electrical conditions in both places. In one of the cities, some of the bonds were located in the negative districts and delivered electricity to the pipes instead of draining off that already in the pipes as intended. The result of making the pipe system a part of the electric railway return system has been to cause enormous currents to flow over some of the pipes. It has been reported that over 3 000 amperes is flowing on a 12-inch gas pipe in one of the cities, and that the pipe is perceptibly warmed by the current.

It is a much more difficult problem to protect a pipe system than it is to protect a telephone system by bonding, on account of its interwoven network of mains and services, large extent, large surface contact with the earth, and uncertain joint resistances. To attempt to protect all of the underground structures by bonding would necessitate the bonding of all of the structures, and of the adjacent parts of each structure together at many points and the draining of the entire structure to the railway return through a booster. That is, to completely protect the structures by this method, each structure must be made negative to every other structure, which is evidently impossible. The nearest we could approach to this condition is to maintain all the structures at the same potential, and this is practically impossible.

Experiments to determine the effect of insulation joints are now being conducted on some systems. The construction of two different types of these joints is shown by Figs. 1 and 2. The joints have a resistance of several hundred thousand ohms when tested dry on blocking in the air. The resistance falls to 100 to 200 ohms when the pipe is filled with water, and falls still lower to only a few ohms when laid in the pipe-line in the ground. What we term the resistance of the joint is, then, the resistance of the shunt around the joint through the ground. The effect of setting the joint at, say, some point near the middle of a pipe-line is to stop the direct flow of electricity on the pipe at that point, and to produce a difference of potential across the joint of some 5 or 10 volts, depending on circumstances. The potential of the section of the pipe-line on the positive side of the joint is raised, and of the section on the negative side is lowered, as a result of the operation. The electrical conditions on the two sections into which the pipe-line is divided by the joint become similar to those of the original line, each section having a positive and negative portion. The efficiency of the joint for decreasing electrolysis depends on many local conditions, such as the number used and character of the ground where they are placed, etc. The result of setting some 6 or 8 on one system consisting of two lines of 48-inch pipe, each about 8 miles long, has been to reduce the total current leaving the pipes by about 30 to 50 per cent.

The insulation joint method, like the bonding method, is liable to produce conditions which will cause increased action on adjacent structures, but there is the distinct difference between the two methods, that the bonds increase the currents on the underground system to a maximum, while the insulation joint reduces the currents to a minimum.

In England, the government authorities have prevented

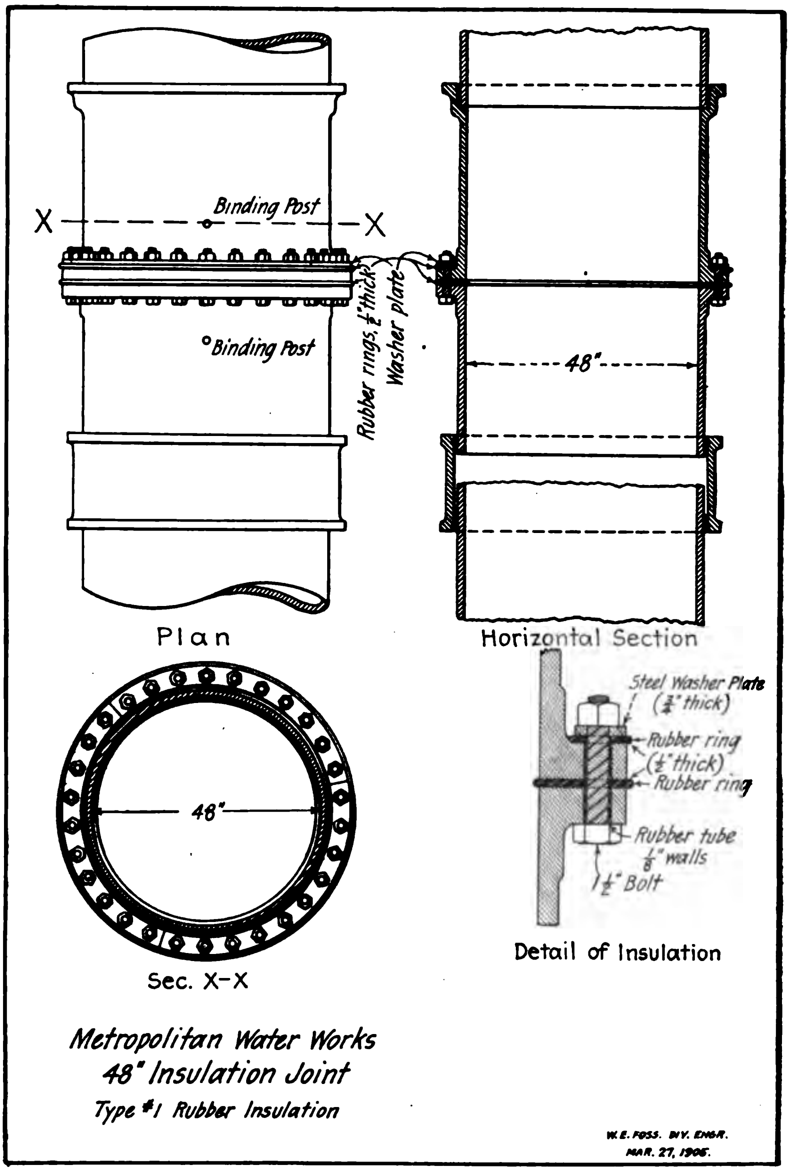

Binding Post
X
X
Binding Post
Rubber rings, ½" thick
Washer plate
48"
Plan
Horizontal Section
Steel Washer Plate
(¾" thick)
Rubber ring
(½" thick)
Rubber ring
Rubber tube
⅛" walls
½" Bolt
Detail of Insulation
48"
Sec. X–X
Metropolitan Water Works
48" Insulation Joint
Type #1 Rubber Insulation
W. E. FOSS. DIV. ENGR.
MAR. 27, 1905.

FIG. 1.

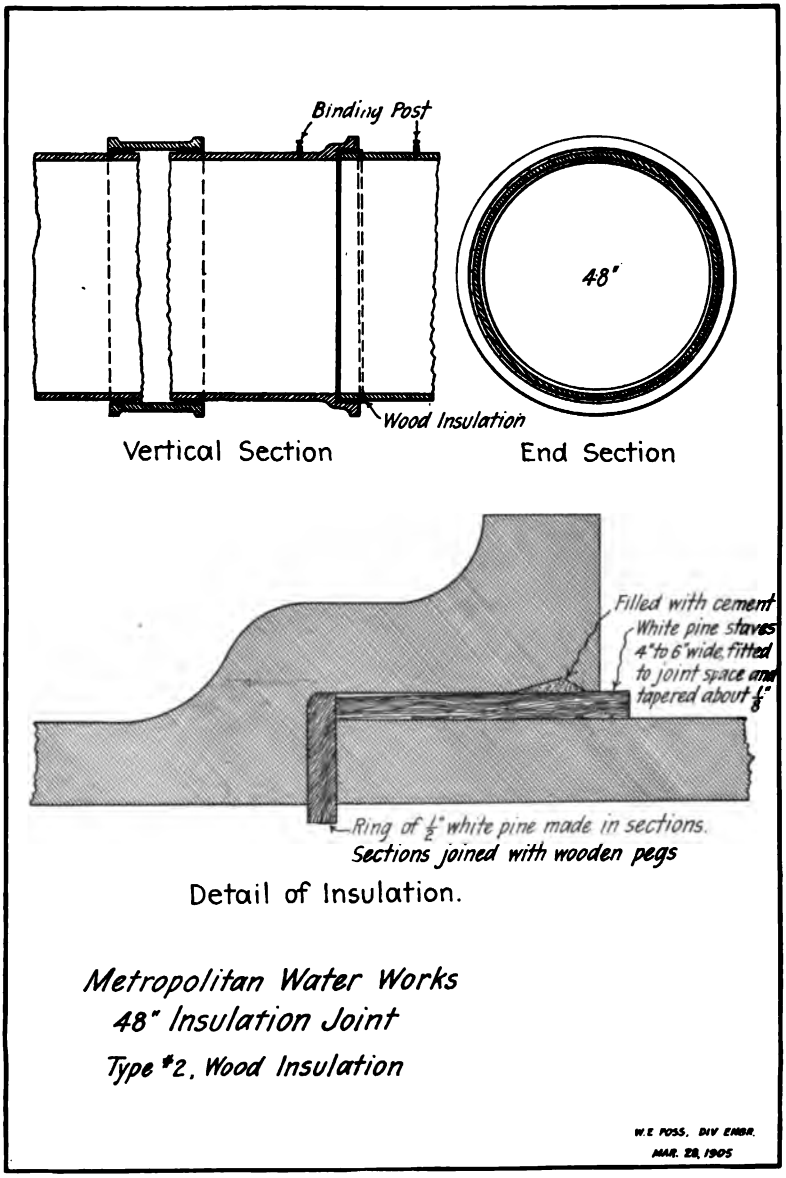

Binding Post
48"
Wood Insulation
Vertical Section
End Section
Filled with cement
White pine staves 4" to 6" wide, fitted to joint space and tapered about ⅛"
Ring of ½" white pine made in sections.
Sections joined with wooden pegs
Detail of Insulation.
Metropolitan Water Works
48" Insulation Joint
Type #2, Wood Insulation
W.E. FOSS, DIV ENGR.
MAR. 28, 1905

FIG. 2.

electrolysis in a large measure by regulations which provide that the maximum difference of potential between any two points on a single-trolley electric railway return system must not exceed 7 volts, and that the railway company shall keep records of the maximum difference of potential and report to the authorities at stated intervals. The results from these regulations are reported to be very satisfactory, and undoubtedly they have prevented a large amount of damage. As the amount of electrolysis in any given district varies directly with the potential differences maintained on the railway return system, the reduction of these differences to a minimum should be the first step to take to reduce the damage which is being done. If the English regulations were applied to the railway systems in the United States, the amount of damage done by electrolysis would be reduced by 60 to 90 per cent.

The protection of pipe-lines from electrolysis by means of insulating coatings has been tried experimentally. All of the coatings applied to pipes after they had been laid in the ground have failed to protect the pipes. Asphalt, tar and burlap, electric tapes and cement have been used as coatings. Several other insulating coatings applied to short pieces of pipe have shown high insulation values in laboratory tests, but we have not yet obtained any reliable data regarding their practical value.

THE PRESIDENT. We should like to hear from Mr. Gould on the gas companies' experience.

MR. JOHN A. GOULD.* I do not know that I have anything new to say on this subject. The gas pipes never were so badly affected as water pipes, although we have had some trouble, but I think less at the present time than we used to have. We had to take out one cast-iron main, which had been laid five or six years; but that was some seven or eight years ago, and I think that is the last one destroyed by electrolysis. We have had service pipes destroyed in eighteen months. I think the troubles in Boston are decreasing. We never have had so much trouble here as they have had in Cambridge, and less trouble with gas pipes than with water pipes. I suppose one reason is that we make a good many cement joints, which make a poorer conductor than lead, and then the water itself in the water pipes is a good conductor, while gas has no conductivity. I know of one case of a gas main which has been laid with insulating joints, parallel with a trolley line where they were liable to be troubled by the return current, and up to the present time there has been no trouble that I have heard of. This line has a rubber gasket at every joint. It is a high-pressure line requiring special care, because if it gave out, the gas, being under 10-pound pressure, would create considerable disturbance. I suppose that there will really be no final solution of this problem until the trolley lines use the alternating current, and then our troubles in this direction will cease.

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* Engineer, Boston Consolidated Gas Company.

MR. T. C. GLEASON.* About six weeks ago I took out some wrought-iron pipe, and although I had never had any trouble with electrolysis so far as I knew, the pipe looked so peculiar that I brought a specimen of it down here to-day thinking that there would be some gentleman present who could inform me whether this shows electrolytic action or not. I should like to have you look at it and see what you think about it. (The specimen is passed around for examination.)

MR. R. C. P. COGGESHALL.† Mr. President, in our city we have not yet, so far as we know, had any serious trouble with electrolysis. Our steel force main, however, which leads from our pumping station 11 miles outside of the city, is crossed about two miles below the pumping station by the street railway line that runs from Middleboro to New Bedford. A short distance below the pumping station a 2-inch service pipe taps into this force main and leads out into the road crossing beneath the tracks of the trolley line where there is a brook, and then continues to the engineer's house. At the brook, we have had four lines of pipe completely destroyed, and Mr. A. A. Knudson, a member of this association, has been called upon two or three times to investigate the trouble. The current apparently passes upon the pipe at the place where the track crosses the large main two miles below the pumping station, and returns upon the force main and the 2-inch service pipe to the brook crossing, where it leaves the pipe and returns to the rails.

About a year ago a young man named Cecil T. Wilkinson, who is connected with the General Electric Works at Schenectady, passed his vacation with us, and the subject of electrolysis coming up, he was at once interested. He said he had made it the subject of a good deal of study in England, and he was very much interested in Mr. Brooks's Cambridge report, a copy of which I obtained for him. Last summer he passed his vacation with us, and of his own volition took the instruments and went out and made an examination. One little suggestion he made may be of interest. I don't know how much value there is in it, but he told me the same thing that Mr. Foss has told us, that they had taken care of this trouble a good deal better in England than they appeared to have done in this country. Speaking of this pipe he says:

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* Superintendent of Water Works, Ware, Mass.

† Superintendent of Water Works, New Bedford, Mass.

" Another alternative, perhaps less expensive, which I have carefully discussed with our railroad engineers " — that is, the engineers at the General Electric Company — " would be to put the 2-inch service pipe now installed in a wooden trough containing unslacked lime, this trough to run about 50 feet south of the point where the rails pass over the pipe and about 150 feet north of that point, or 200 feet in all." .

Then in a later letter he says:

" With regard to the discussion of this subject at the meeting of the New England Water Works Association, if the opportunity occurs for you to mention the use of lime, I would be very glad to have you do so.

" When tar, or paint, or cement of like nature is used as a coating for water pipes to protect them against the electrolytic action, there almost invariably occurs the formation of pockets in which the saline matter of the soil collects, causing very vigorous action at certain points. The complete success we have had on a small scale and under suitable conditions with unslacked lime is not remarkable when you consider that it is theoretically the absolutely correct thing to use. Electrolytic action is due only and entirely to the sulphides, chlorides and nitrates dissolved in the soil, and when the water from a rainstorm percolates through the earth, it carries down on to the surface of the iron pipe all these acid salts in solution. If, therefore, before reaching the pipe it passes through a layer of a few inches of lime, all these salts are neutralized and no action whatever occurs. We have even found the surface of the pipe entirely free from all traces of pitting when other metal unprotected in this way has been completely pierced with holes. If any member of your association wishes to try this scheme I shall be very glad to hear how he succeeds.

"To be perfectly frank, I do not at the present know definitely why it is better to use the lime unslacked when first put on to the pipe, but undoubtedly better results are achieved in that way."

THE PRESIDENT. I am told, Mr. French, that you have had some trouble with electrolysis.

MR. A. N. FRENCH.* I don't think I can add anything to what has already been said, Mr. President. We have had some little trouble on our service pipes, but nothing very serious on our mains, and we are learning something every day. We have had one case of electrolysis under a steam railroad which seemed a little peculiar.

MR. HORACE G. HOLDEN.† I should like to inquire, Mr. President, whether any water departments or water companies have ever received any payment of damages from the trolley companies on account of electrolysis. It seems hard if the water company has to stand all the loss.

MR. COGGESHALL. I will say that in our case the Old Colony Railway Company, which has been the source of our trouble, has been paying the bills for repairs.

An interesting point that has come up in our town has been in connection with the electric road itself. Its power plant is located on the water front and it draws the condensing water from the river and delivers it into the river, and one of the pumps has been completely destroyed by the return current which came from the river into the hot-air pump.

THE PRESIDENT. The electric roads themselves have started to look out for their rails by going over their entire track with a car provided with apparatus which will give them a definite spot where the current leaves the rails; and when that is done, if they will take care of it and remedy the trouble at those points, we are going to get rid of a good deal of our difficulty. I tried to get a representative of the railroad company to come here to-day and explain the apparatus, but he was not able to come. At some future time if we can have him here I think it would be very interesting. Would any one else like to speak on this subject?

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* Superintendent of Water Works, Hyde Park, Mass.
† Superintendent of Water Works, Nashua, N. H.

Mr. Brooks. I may say, Mr. President, that I have found that the railroad company is very cautious about recognizing the word "electrolysis." It is willing to pay in some cases for repairs but it doesn't want "electrolysis" or "electrolytic action" spoken of in the bill. We can call it by any other name we like, but we steer clear of that.

Mr. J. C. Hammond, Jr.* We have had three of our lead services completely honeycombed, and we don't know what else to lay it to except electrolysis. I would like to ask if any one has had any such experience as that.

Mr. Brooks. I will say, in answer to Mr. Hammond, that when the West End power station was first established at East Cambridge the city tried using lead services down there and found them of no use at all. They went more rapidly even than the iron pipe, and so the idea of protecting the services by having them of lead was abandoned.

Mr. Edward V. French.† Mr. President, isn't it a fact that whenever a current gets on to a pipe, even if you provide a proper means for it to get on and a proper means for it to get off, there is likely to be a good deal of trouble at each joint, or at least at the joints which happen to be rather poor conductors, because of the way the lead or oakum happens to be put in?

It seems to me that this is an exceedingly important question, involving, if the trouble goes on, the expenditure of a great deal of money in some places to repair the damage which is probably being done, especially if the trouble is going on in this somewhat hidden way only to show itself unexpectedly some day. I was wondering whether the study of the subject has gone far enough so that it would be possible for the association or a committee to make some definite suggestions for the detection and the remedy of the danger. Perhaps in the large cities the railway companies are watching conditions very carefully, and I do not know exactly what the present condition of the whole work is, but it occurs to me that it is a matter of so much importance that if the association could suggest some standard means of finding the trouble and some method of remedy, it would be a distinct gain in the long run. It may be that things are not in condition so that this can be done, but the idea occurred to me and I thought it was worth expressing.

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* Treasurer, Water Company, Rockville, Conn.

† Inspector, Associated Factory Mutual Insurance Companies, Boston.

MR. GEORGE E. WINSLOW. Mr. President, there has been a good deal said here at times against a certain kind of pipe that has caused a good deal of trouble in other ways than from electrolysis, namely, the old cement-lined pipe. Hiram Nevons, while superintendent at Cambridge, at one time said that a cement pipe could be made which would be the best pipe in the world, by taking the ordinary cast-iron pipe that is used at the present time and lining it with cement and covering it with cement. I think so, too. And, furthermore, — I am talking on a subject that I am not very familiar with, and perhaps I may say something which is wrong, but you will take it for what it is worth, — there is a good deal of resistance in cement to the flow of electricity, how much I don't know. I do not know, however, of any place where cement pipe is in use where electrolysis has affected the mains. I know also that when lightning strikes a cement pipe and breaks it, which it sometimes does, the break is generally in the joint where the end of the pipe is exposed to the water. The question has been in my mind ever since this discussion began here to-day as to the feasibility of insulating the mains by cement and thereby perhaps getting something by which we will obviate the danger of electrolysis, or will stop the rusting of the pipes and other things of like nature, as a cement pipe never fills up. I want to assure you that I am not in favor of cement-lined pipe as ordinarily made of thin sheet iron covered inside and outside with cement, and I certainly should want something a little stronger than that. I merely speak of this as a suggestion in the way of insulation.

MR. FOSS. I think that Mr. French's experience in Hyde Park will be of some interest. Mr. French had trouble with his service pipes, and he finally boxed one of them in a wooden box and filled it up with cement, and a year or so afterwards he had to go and relay the pipe, so that the cement as put in at that time certainly did not stop the action. Regarding the point brought out by Mr. Edward V. French, I think that with the improvements made during the past few years in methods of investigating electrolytic troubles, there is no reason why we cannot locate any action that is going on. We can now measure the current flowing on the pipe and follow it down to where it is leaving the pipe, and, in general, locate the bulk of the damage. We cannot locate every point where damage is being done, but we can obtain a very good idea of the total damage, and the location of it.

Mr. Foss (*by letter*). Mr. Gould has suggested that troubles from electrolysis would cease when the street railways adopted the alternating current instead of the direct current. This is, perhaps, a natural conclusion from the alternations of polarity, but does not seem to be a fact, for, as shown by the following quotations, alternating currents apparently cause nearly as much electrolytic action as do direct currents.

Dr. Guglielmo Mengarini says, in *The Electrician* (London), Vol. 27, p. 336, July 24, 1891:

> In a voltmeter containing acidulated water, or a saline solution, the quantity of the electrolyte decomposed at an electrode by an alternating current (the current density at the electrode and the number of alternations remaining constant) increases if an obvious recombination of the gases at the other electrode takes place. Owing to this recombination, a direct current is superimposed on the alternating current, modifying its character.
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> In this way, with alternating currents, metallic deposits of copper, silver, nickel, etc., quite equal to those produced by direct currents can be obtained.
>
> . . . .
>
> During electrolysis by alternating currents, the electrodes are vigorously attacked and quickly destroyed.
>
> Even platinum, gold, and iridium become covered with a powder which increases until it finally completely destroys the electrode.

Abstract from "Alternating Current Electrolysis," by Prof. Ernest Wilson, in *The Electrician* (London), Vol. 48, p. 1025, April 18, 1902:

> *Experiment with pure lead.* Electrodes of the same size as for previous experiment were cut from a sheet of pure lead, and two electrolytic cells were prepared with dilute sulphuric acid as electrolyte. In each case the current had about the same density

of 0.024 amperes per square centimeter of active surface, but the frequencies were 92.5 and 21.5 respectively. . . . The plates were weighed before and after the experiment. It will be seen from the table that the total diminution in weight, which was equally distributed between the two plates in a given cell, is nearly twice as great at low frequency as it is at high frequency. A test made by Mr. Skelton, in the Chemical Department at King's College, London, shows that the deposit at the bottom of each cell is lead sulphate. . . . In this experiment, the ratio of the maximum coulombs at 92.5 and 21.5 periods per second is 0.23, . . . and the ratio of the diminution in weight 0.54. The average watts during the experiment are nearly the same in each case. These results indicate that frequency plays an important part in the reaction.* Pieces of the same sheet of lead immersed in a portion of the same electrolyte are only slightly discolored in the same time, so that it is the electric current which produces the effect.

Average frequency in periods per second during experiment	92.5	21.5
Total weight of the two plates in grams before experiment	801.167	798.084
Total weight of the two plates in grams after experiment	784.667	767.884
Total loss in weight in grams	16.5	30.2
Area of active surface of each plate in square centimeters,	160	160
Time current was passing through each cell in hours	15	15
Distance between plates in centimeters	0.317	0.317
Average of amperes during experiment	3.74	3.80
Average of amperes per square centimeter of active surface	0.0236	0.0236

(From Minutes of Proceedings of the Institution of Civil Engineers, Vol. 149, 1902.)

Philip Dawson (p. 96) said: His experience, with the fairly low frequencies which must be adopted for traction with alternating currents, was that the electrolytic action was nearly as bad as with continuous currents; the difference was that with continuous currents the resulting damage was limited to an area which could be predetermined, and safeguarded by means of additional return cables or negative boosters; whereas with alternating currents the area was not limited, and the damage was likely to be caused over the whole system.

W. H. Massey (p. 100) said: With regard to alternating currents and electrolysis, experiments he had conducted about four years ago had left no doubt whatever that, provided the frequency was low enough and the current sufficiently large, electrolytic action occurred just as badly, or was even worse, with alternating currents than with continuous currents.

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* In alternating current railway work, a frequency of about 25 cycles is employed at the present time. — ED.

W. H. Molesworth (p. 101) said: The electrolytic action of alternating currents of low frequency, as advocated for railways, was as serious as that due to continuous currents.

W. M. Mordey (p. 161) said: It had been stated that alternating-current electrolysis was worse than continuous current; as a matter of fact it did not seem to be as bad, at least, with such low-current densities as were likely to be met with in railway practice. It only began with a current density that would give enormous deposition with continuous currents. In the experiments of G. Mengarini on the electrolysis of liquids,* it had been shown that until a density of four amperes per square inch was obtained there was no electrolysis at all. With continuous currents there would be large volumes of gas coming off with such a current density as that.

(From Minutes of Proceedings of Institution of Civil Engineers, Vol. 151, 1903.)

A. P. Trotter (pp. 96, 97), in discussion on Electric Tramways, said: He had felt that it was not likely alternating currents would be free from corrosion; and, taking two pieces of lead pipe, one of which was on the table, he had buried them in moist earth in a box, and had subjected them for a month to an alternating current, from Deptford, of one ampere. The two pipes had faced each other, about 4 inches apart. A thick white crust of what he thought was carbonate of lead had formed. It was an interesting fact that the patch was definitely limited, showing that at less than a certain current density, or difference of potential, no corrosion took place. He had used lead because, the electrochemical equivalent of lead being higher, the product of the action was of larger amount than with iron; and further, it was an insoluble white crust which could easily be seen. Recently Mr. Mordey, in reply to the discussion upon his paper, had suggested† that the experiments made by G. Mengarini showed that alternating currents at a less density than four amperes per square inch would not cause corrosion by electrolytic action. He had measured the area of the pipe affected, and had found it to be about 40 square inches; so that about 1-40 ampere per square inch had produced the effect shown. After Mr. Mordey's remarks, he had thought it would be well to make some experiments to ascertain whether there was a critical current density below which no corrosion might be found. He had already tried many experiments on lead wire in the Board of Trade Laboratory with continuous current, in attempting to find such a point; but he had not found it. In his experiments he had not used clay or gravel, but simply ordinary damp soil. Chemists, he believed, gave the name " humus " to the active principle of soil which was supposed to attack the lead. He had started the experiment with alternating current at 83 periods per second, and with the current density at which he had left off in the previous experiment, namely, 1-40 ampere per square inch. Taking four lead plates, each 4 inches square, he had painted them with varnish, with the exception of square spaces in the middle, as shown by the following table:

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* *The Electrician*, Vol. 27, pp. 304 and 334. It appears, however, from this paper that, at higher densities than that given above, the action on the electrodes may be more destructive than with continuous currents; *e. g.*, even platinum electrodes may be acted on and destroyed. See also, R. Malagoli: L'Éclairage Électrique, Vol. 13, p. 255.

† Minutes of Proceedings of Inst. Civil Engineers, Vol. 149, p. 162.

Unvarnished Portions of Surfaces.			Current-Density.	
Plate No.	Front.	Back.	Ampere per Square Inch.	Amperes per Sq. Meter.
1	½ inch x ½ inch	1 inch x 1 inch	front 1-40 back 1-160	38.7 9.7
2	2 inches x 2 inches	2 inches x 2 inches	1-640	2.42
3	3 " x 3 "	4 " x 3 "	1-1440	1.075
4	4 " x 4 "	4 " x 4 "	1-2560	0.605

By the end of a month a thick white incrustation of lead had formed on Nos. 1 and 2, and a thinner coating on the larger plates, the corrosion being apparently proportional to the current density. (The speaker exhibited the plates.) With continuous current the corrosion would probably have been about double. Such experiments were well worthy of attention, and he hoped the National Physical Laboratory, which had much better facilities than he had, would continue them. So far as the frequency of alternating currents was concerned, he would imagine that the lower the frequency, the greater the chance of corrosion. He supposed that since the product was an insoluble salt of lead, what was produced by one phase was not decomposed by the other phase. There was no possibility of protection in alternating-current work by arranging the polarity of the conductor, as there was in continuous-current work.

ON THE PRESENT RELATIVE RESPONSIBILITY OF PUBLIC WATER SUPPLIES AND OTHER FACTORS FOR THE CAUSATION OF TYPHOID FEVER.

BY W. T. SEDGWICK AND C.-E. A. WINSLOW, PROFESSORS IN THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

[*Read November 9, 1905.*]

In a paper read before this Association in 1901, the rise and progress of water-supply sanitation in the nineteenth century was traced with some care. (Sedgwick, 1901.) It was then shown that the responsibility of public water supplies as sources of typhoid fever was first made conspicuous by the epidemics at Lausen, Switzerland, in 1872 (Hägler, 1873), and at Caterham, England, in 1879 (Thorne Thorne, 1880). In this country evidence of the same character was not long lacking; for in 1885 the thriving mining town of Plymouth, Pa., suffered one of the most disastrous water epidemics of which we have even yet any record. (Taylor, 1886.) The great epidemics at Lowell and Lawrence in 1890–91 added new emphasis to the previous lessons (Sedgwick, 1893, *a*); but nevertheless a majority of the largest cities of the United States have continued almost up to the present day to drink water more or less infected with typhoid fever. In the period 1898–1903, there were nineteen cities in the United States of over 200 000 population. Twelve of the nineteen were furnished with public water supplies drawn unpurified from polluted rivers or lakes. The typhoid death-rates in these cities per 100 000 population were as follows (Fuller, Ferguson, and Jeup, 1904):

Pittsburg	122
Washington	66
Louisville	60
Cleveland	51
Philadelphia	51
Cincinnati	45
Minneapolis	42

Chicago	31
St. Louis	31
Buffalo	29
Detroit	18
Milwaukee	18

For the other seven cities not having supplies drawn from grossly polluted sources, the corresponding rates were as follows:

New Orleans	49
Baltimore	35
San Francisco	31
Boston	26
Jersey City	22
Newark	21
New York	19

There are causes other than the public water supply for the high typhoid death-rates in New Orleans and perhaps in Baltimore. Where no such factors are operative the cities with reasonably pure water supplies exhibit typhoid rates ranging from 20 to 30; 25 would be a fair average figure for American cities of this class. The excess over 25 deaths per 100 000 in the case of Pittsburg, Washington, Louisville, Philadelphia, Cincinnati, and Minneapolis is unquestionably the tax paid by those municipalities for their polluted water supplies. In the first five cities alone this needless waste amounts to 1 200 lives per annum.

And yet great progress has been made in the right direction. The replacement of water derived directly from polluted streams, by filtered or well-stored supplies, goes on with increasing rapidity. Jersey City, for example, where the typhoid death-rate ranged from 52 to 94 between 1890 and 1896, in the latter year abandoned the Passaic River at a point where it was heavily polluted by the sewage of Paterson and Passaic, with the result that the rates for the four years immediately succeeding fell to 21, 36, 15, and 21. Albany effected an equally striking reduction in its typhoid death-rate when a municipal filter was introduced in 1899. (Fuller, Ferguson, and Jeup, 1904.) Of the other communities mentioned above, Washington and Louisville have installed filtration plants within the present year. Philadelphia's system is partially installed, and one of the most serious indictments against the one-time bosses of that apparently redeemed city is the charge that the delay in the completion of this sanitary work is responsible for 1 200 deaths from typhoid fever. Pittsburg and Cincinnati, too, have begun the construction of municipal filter plants, and before many more years the large American city which drinks the unpurified water of a stream, or of a lake with unprotected watershed, will be an exception and an anomaly.

Of special interest in this connection are the statistics of the state of Massachusetts, where the supervision of the public water supplies has been more thoroughly carried out than in any other American commonwealth. In the period 1886–90, the typhoid death-rate for Boston was 39 per 100 000, and for Newton, with an excellent ground-water supply, was 40. The rate for all the cities of the state taken collectively was somewhat higher (46), and the two large cities of Lowell and Lawrence, using the polluted water of the Merrimac River, had each a rate of 112. As later events showed, two thirds of the typhoid fever in Lowell and Lawrence was caused by water, and this excess, of course, materially raised the rate for the total urban population of the state.

Between 1891 and 1895 the unpurified river-water supplies of Lowell and Lawrence were abandoned, and for the period 1896–1900 their rates fell to 25 and 24 respectively. In at least one of these communities, Lowell, the present water supply, from a series of driven wells, is absolutely protected from infection. In Newton with a rate of 20 and in Woburn with a rate of 13, the conditions are similar. Gloucester, Pittsfield, and North Adams, with rates of 16, 25, and 39 respectively, possess surface supplies of unexceptionable quality from uninhabited watersheds, probably as free from pollution as such waters can often be.

The North Adams typhoid rate may be regarded as due to certain exceptional conditions. We may, however, consider the other five communities as typical of most of the cities of the state, differing only in the fact that our knowledge of the purity of their water supplies is more certain than in other cases. In these five cities we find typhoid rates of 13, 16, 20, 25, and 25. We are confident that these rates are not raised by pollution of the public water supplies and that the influence of private well water upon them is negligible. It therefore follows that typhoid deaths ranging from 15 to 25 per 100 000 are due in these cities to causes other than polluted water; and it is probably fair to assume that at present in similar American communities about this amount of typhoid fever may be expected to occur without its intervention. When we find that the typhoid rate for the whole of Massachusetts in 1896–1900 was only 24, in 1901 only 19, and in 1902 only 22, it seems evident that in this state at least public water supplies are not factors of paramount importance. Eternal vigilance is, of course, the only price of freedom from water-borne typhoid. Particularly in the case of unfiltered surface supplies, such as are common in New England, danger must always be recognized as possible. The 450 cases of typhoid fever at New Haven in 1901 (Smith, 1902) were caused by temporary pollution on a watershed quite as good as that of many a supply in Massachusetts. So great is the danger of such a mishap that as the country becomes more densely populated it must eventually be recognized that no surface water is safe for drinking without purification. Even with filtered supplies only careful and constant supervision will insure safety. Witness the 1 270 cases of typhoid fever at Butler, Pa., in 1903, due to almost criminal carelessness in the operation of the filter plant of the local water company. (Soper, 1903.) The responsibility which rests upon water-works officials still remains, and must always remain, heavy; but, broadly speaking, when this responsibility is well discharged, we may say with confidence, in the light of the expert knowledge at our disposal, that public water supplies play an insignificant part in the causation of typhoid fever in New England.

It must also be remembered that our requirements as to the purity of our supplies have all along been steadily rising and that a far higher degree of purity is to-day demanded, and rightly demanded, in water supplies than was formerly expected or possible. The extraordinary demonstration furnished by the experience of the city of Lawrence with filtered water, in which it has been shown by Mr. Hiram F. Mills and by Hazen (Hazen, 1905) that the general death-rate has been reduced much more than the typhoid death-rate, can only mean that the germs of other common diseases besides typhoid fever are carried by water, unless, indeed, it turns out in the future, as is possible, that the vital resistance of the people using the water has been increased, as the purity of the water has risen. Either alternative is extremely suggestive for water-works officials, and opens out inviting fields for investigation and research.

With the progress of sanitary reform the relative responsibility of water for typhoid fever necessarily decreases. As recently as 1902, Mr. M. N. Baker wrote, " Not only is typhoid one of the leading causes of death in America, but the greater part of it is conveyed, directly or indirectly, through water." (Baker, 1902.) This is still true in Philadelphia and Pittsburg, but it is not true to-day, as we have seen, in Massachusetts. Meanwhile, year by year the relative importance of what we may call the *residual typhoid* becomes greater. It is increasingly necessary that the attention of sanitarians should be directed to that tax of 15 to 25 deaths (which means 150–250 cases) per 100 000 population, which typhoid fever still levies on communities provided with ever so pure a water supply. To what shall we attribute this residuum of the disease, so constantly present in most American cities?

In attacking this problem, which concerns not only the epidemiologist but also the practical water-works official who desires to know just how far the water supply under his care may justly come under suspicion, we must begin by remembering that the extension of an infectious disease is the spread of a microscopic parasite; and that this follows much the same course as the distribution of any higher plant. Wheat comes from the ear and eventually finds its way to a favorable soil where it may sprout. So the seed of typhoid infection originates in the body of the typhoid patient and germinates in the intestinal canal of a susceptible victim. The intermediate steps in the history of the wheat may be various. The wind, or a bird, the hairy coat of an animal, or the hand of man, may carry the grain from the place of its origin to the new soil where it sprouts and multiplies. Equally diverse may be the paths by which the typhoid germ is propagated from person to person. Air, earth, water, milk, fruit, flies, soiled clothing, human beings, may intervene; or the transfer may be so direct as to require no intermediary save the two individuals chiefly concerned.

The more we study the prevalence of typhoid fever, the more it becomes evident that its spread goes on in two ways. The first is that in which infection is distributed by a single common medium to a large number of persons at one time. This is characterized by the sickening simultaneously, or at least within a period of a fortnight, of a number of persons who have, perhaps, partaken of some common article of food. Such an explosive outbreak is what the public generally means by an epidemic. Sometimes, on the other hand, we find an undue prevalence of typhoid fever without such coincidence in time and, therefore, of exciting cause. An excessive number of cases of the disease occur which cannot be connected by any common epidemiological bond, but follow each other in a slow succession of scattered or sporadic cases, or in that closer association as to locality to which the older sanitarians applied the word "endemic." As this word is outworn, because by custom associated with the idea of some mysterious but wholly intangible quality inherent in a definite soil or region, the term *prosodemic* has been suggested by one of us for this form of disease " which progresses gradually from person to person by routes which, whether direct or indirect, are often different for each individual case," the term *epidemic* being restricted to " that special case in which circumstances permit the transfer of infection to a large number of persons through the same medium, and at approximately the same time" (Winslow, 1901).

True epidemic typhoid, in the sense in which we have thus defined the word, is generally easy to trace back to its exciting cause. The coincidence of cases fixes the date of infection with approximate accuracy, and the scope of inquiry is at once narrowed down to those vehicles of infection to which all the sufferers have been jointly exposed. Furthermore there are comparatively few methods by which typhoid infection is likely to be transmitted to a large number of persons at the same time. The vast majority of recorded epidemics have been traced with reasonable certainty to one of three vehicles, water, milk, or shellfish. Of these water is by far the most important.

The residual typhoid which still afflicts American cities and large towns, even after they have acquired good water supplies, is undoubtedly due partly to occasional epidemics in which the vehicle is some material other than water, — such as small milk epidemics, shell-fish epidemics, celery epidemics, and the like, — even where outbreaks of notable size, in which the infection of a large number of persons can be traced to a common source, are absent. Outbreaks due to milk, although considerable, account, however, for but an insignificant proportion of the total and constant annual mortality; and epidemics distinctly traced to shell-fish and raw vegetables have been still more exceptional.

Most of the typhoid cases which occur to-day in Massachusetts and in other communities provided with reasonably good water supplies, are of the sort we have designated as "prosodemic." They are transmitted from person to person by routes which differ in individual cases. The methods by which infection spreads are almost infinite in number. The chain begins with excreta and ends usually with food; but the intermediate links may be few or many. The fingers of unprofessional attendants upon typhoid patients, or of the patients themselves during the early stages of the disease, and flies, which so often pass freely from infected privies to adjacent larders, suggest themselves as ready vehicles. Sometimes the route is so direct that typhoid fever, under uncleanly conditions, becomes for all practical purposes a contagious disease. Sometimes it is so roundabout as to baffle any attempt to trace it.

The devious and obscure course of prosodemic typhoid is no new discovery. It has never been shown more clearly than by Dr. William Budd in his famous monograph published in 1873. (Budd, 1873.) The little village of North Tawton in England suffered a severe outbreak of this character in 1839, over eighty cases occurring between June and November of that year, following each other slowly, several members of a family taking the disease in almost every house in which it appeared. Three infected persons left the place during this summer, and each one formed a new focus for the spread of fever in a region hitherto free from it. In the first case the two children of the sufferer succumbed to the infection; in the second case a friend who acted as nurse took the disease and in turn transmitted it to his two children and his brother; the third of the visitors left North Tawton to stay with a brother at another hamlet seven miles.

away; the brother's wife, the brother himself, two farm hands, a friend who had come to take charge of the house, another farm hand, two servants, and the daughter of the original visitor successively developed typhoid fever. Evidence of the direct transmission of the disease could scarcely be more conclusive.

In this country the outbreak at Bondsville, Mass., where one hundred cases occurred among the mill operatives in the summer of 1892 (Sedgwick, 1893, *b*), and that of Newport, R. I., in 1900, in which some forty cases, apparently caused by an infected well, were followed by double that number of secondary cases (Winslow, 1901), furnish more recent examples of the same phenomena. In each of these instances the slow succession of cases and the bond of physical association between the victims gave evidence of the prosodemic character of the disease.

There can be little doubt that the emphasis on water and milk epidemics, which produce a striking effect upon the public mind from the number and coincidence of the resulting cases, has led to a general neglect of the less obvious but equally grave danger involved in the spread of prosodemic typhoid. Even the well-water theory may be overworked, for long ago Dr. Rolleston remarked: "And I would add that certain observations which I made recently in a fever stricken village . . . have induced me to think that of the two recognized foci for infection [in typhoid fever], the bespattered privy and the contaminated well, the former may be the one which is more commonly at work." (Rolleston, 1869.) The doctrine that typhoid fever is "infectious but not contagious" has slain its thousands. In dirty surroundings, typhoid is essentially a contagious disease. Even among trained attendants, with all the advantages of a hospital environment, the number of secondary cases of typhoid is considerable. Collie has recorded that one hundred cases occurred in the staff of the Asylum Board Hospitals of London from 1892 to 1899. (Collie, 1904.) In the unsanitary conditions which, to our national disgrace, prevailed in the camps of our volunteer soldiery during the Spanish War, the conditions favorable to the transmission of disease reached a maximum and furnished a striking object lesson in the transmission of prosodemic typhoid. (Reed, Vaughan, and Shakespeare, 1904.) Of 107 973 officers and men in the national encampments during the year 1898, 20 738, or nearly one fifth, developed typhoid fever, with 1 580 deaths. The disease was spread in a series of independent company outbreaks affecting over 90 per cent of the volunteer regiments within eight weeks of their assembly in camp. Infected water played no important part. Flies undoubtedly served as carriers of infection, and it was believed that the virus was disseminated to some extent in the form of dust. The vast majority of the cases, however, were caused by more or less direct transfer of infected material under unsanitary conditions. Of 1 608 cases which were studied in detail, 62 per cent were definitely connected in place and time with earlier cases. The chief factor controlling the incidence of the disease was the system used for the disposal of excreta. Thus, in the Seventh Army Corps, the First Division, with a water-carriage system, had 1 030 cases of typhoid fever; the Third Division, with regulation pits for disposal, had 1 292 cases; the Second, with the thoroughly unsanitary " tub " system, had 2 693 cases. This history of typhoid in the army is simply the history, on an intensive scale, of all prosodemic typhoid.

One of the most interesting features of the " residual typhoid " (not due to polluted water supplies) is its definite seasonal prevalence. In communities provided with reasonably pure water supplies, the typhoid, or as it was called by the older sanitarians, the "fall fever," follows the curve of seasonal temperature with extraordinary regularity. If the monthly deaths from the disease be plotted and compared with the monthly temperature it will be found that the curves are almost parallel, the typhoid fever rising with the temperature after about two months, an interval representing the incubation period of disease and the time which elapses before death. Where the temperature curve is acute, that of the mortality follows it, whereas in a mild climate, the distribution of the disease is more even. In the southern hemisphere both curves are reversed. We have elsewhere shown that these phenomena are so constant and so universal as to suggest in the strongest manner a direct relation between temperature and typhoid fever; and our theory of this relation is as follows:

"The bacteriology and the etiology of typhoid fever both indicate that its causal agents cannot be abundant in the environment during the colder seasons of the year. The germs of the disease are carried over the winter in the bodies of a few patients and, perhaps, in vaults or other deposits of organic matter where they are protected from the severity of the season. The number of persons who receive infection from the discharge of these winter cases will depend, other things being equal, upon the length of time for which the bacteria cast in the discharges into the environment remain alive and virulent. The length of the period during which the microbes live will depend largely upon the general temperature; as the season grows milder, more and more of each crop of germs sent at random into the outer world will survive long enough to gain entry into a human being and bear fruit. The process will be cumulative. Each case will cause more secondary cases; and each of the latter will have a still more extensive opportunity for widespread damage. In our opinion the most reasonable explanation of the seasonal variations of typhoid fever is a direct effect of temperature upon the persistence in nature of germs which proceed from previous victims of the disease." (Sedgwick and Winslow, 1902.)

In cities having polluted water supplies there was an interesting departure from the normal seasonal distribution of typhoid. We found the normal maximum in September or October; but in some cases there were also secondary maxima in the fall and spring as shown in the curves for Chicago. These high death-rates in the cooler months were at first puzzling, and such instances have obscured the usual seasonal variations and led some sanitarians to deny the existence of any relation between typhoid fever and temperature. As soon, however, as it appeared that curves of this type were associated with polluted water supplies, their significance became clear. The fall and spring epidemics coincide with the fall rains and the spring thaws, which wash infecting material from vaults on the banks, or through storm overflows, into the water supplies, carrying it fresh and virulent to the consumers below. A seasonal distribution of this sort appears to be characteristic of many communities drinking from unprotected surface waters; and it was found by us in this country in Chicago, Cincinnati, Newark, and Philadelphia. On the other hand the large majority of cities, including Atlanta, Baltimore, Boston, Charleston, Denver, Mobile, Montreal, New Orleans, New York, St. Paul, San Francisco, and the District of Columbia showed a close and constant relation between the temperature and the seasonal prevalence of typhoid fever.

It is obvious that the difficulties of tracing the path by which prosodemic typhoid spreads in the individual case must often be insuperable. In a crowded community there are so many possible modes of transfer in each separate instance that it is generally impossible to demonstrate the chain of infection, as may often be done in an epidemic inflicted on a number of persons at a definite time and by a single common cause. As intermediate vehicles of the disease, we may have soiled clothing, or bedding, or the woodwork of privies, water, milk, celery, lettuce, or fruit. Food, fingers, and flies offer an alliterative summary of the most common agents. The one thing upon which we can fix our attention with certainty is the common point of departure. Every germ of typhoid fever, whatever its subsequent history, originates in the body of a typhoid patient and leaves it in the excreta. Every case of typhoid fever is due to the presence of excreta on food or fingers, or in some other place where excreta should not be. Filth is the fundamental condition for the spread of typhoid fever; cleanliness the universal panacea for its eradication.

Exactly how much responsibility ought to be assigned to each of the individual factors it is not always possible to say, and we need, therefore, to be particularly careful not to jump too hastily to conclusions. As regards flies, for example, we must remember that while these are unquestionably important vehicles in the spread of typhoid fever, the striking fact remains that the time of greatest mortality from typhoid fever in Massachusetts is not such as to justify, offhand, a belief that flies are the principal vehicle of that disease in this state; for, while typhoid mortality reaches its maximum about the middle of September, a fact which demonstrates that the germs are received by the inhabitants in greatest numbers or under most favorable conditions at some time in August, it is generally believed that September is often, if not always, the worst month of flies. On the other hand, the truth may be, of course, that even if flies are more *numerous* in September they are less *active* than in August, and we must therefore be careful not to dogmatize on either side without sufficient evidence. One fact which stands out with especial clearness the longer we study the subject is that in spite of all that may be, and has been, said to the contrary, *typhoid fever is a contagious disease.* Instead of saying, as is often said, that " typhoid fever is infectious, not contagious," we need to say to-day that " typhoid fever is both infectious and contagious "; and, doubtless, it is in part for this very reason that it has been found so difficult to exterminate.

The conclusion of the whole matter is perfectly clear. Dirt and disease go generally hand in hand, and the importance of disinfection as near as possible to the source of discharge becomes more and more obvious every day. It is plainly wasteful as well as dangerous to allow disease germs to escape from their original sources of supply and become distributed in the environment. Extraordinary pains are therefore requisite in order to destroy their dragon's brood at the very outset, and we cannot help feeling that boards of health are here often remiss. Too often boards of health content themselves with routine work; too often they are more careful for their own political lives than for the lives of the people whom they serve. What we greatly need at present in many of our cities and towns is greater *activity* and *aggressiveness* on the parts of boards of health, especially in respect to sanitation as opposed to hygiene, so that disinfection shall be more carefully done, so that polluted wells, which are still frequently in evidence in many of our thriving towns and cities, shall be closed up, and so that privy vaults and other primitive methods of disposal of excreta which are unfortunately too characteristic of American cities and towns, and whose disappearance is a sure index of effective civilization, shall be cleaned up and done away. Meantime, all good citizens should uphold boards of health in all their reasonable activities, and contribute as far as they can towards that enlightened public spirit which shall insist upon a higher standard of cleanliness in all our cities and towns. But even all these things are not enough. We greatly need an extension of power in our state sanitary authorities so that these shall be not merely advisory and judicial, but shall have, besides the power and duty of investigating and reporting, some measure of *control,* so that when local authorities are neglectful or powerless, a higher authority may step in and protect the lives and health of the people; for local carelessness, neglect, or ignorance may, and often do, entail the widespread injury of states and even nations. In Massachusetts, for example, we ought to have some system of district sanitary or public health inspectors, and some system of centralized authority similar to that which we have in the state medical examiner system, a system which has replaced with so much advantage the antiquated " coroner " system of former days.

This is an old story. Yet as long as conditions remain unimproved it is a story which must again and again be repeated. The authors of this paper presented a communication bearing a similar title before the American Public Health Association at its New Orleans meeting in 1902, with the following conclusions (Sedgwick and Winslow, 1903): *First*, that in the state of Massachusetts and in some of the larger cities of the United States the public water supplies are now relatively unimportant as vehicles of typhoid fever.

Second, that in cities having pure water supplies the annual curve of typhoid fever mortality closely follows that of annual temperature.

Third, that in urban communities supplied with pure water there still remains a typhoid fever tax of from 15 to 25 deaths per 100 000 population. (To this we now give the name *residual typhoid.*)

Fourth, that this tax is due, not to any peculiar condition of soil, locality, or climate (" endemic " factors), but to incomplete disinfection of typhoid excreta, with subsequent infection of various articles of food and drink. These factors, when acting upon a few or many persons at one time, may cause obvious epidemics, sometimes large, through generally small; but more often the infection in moving from one point to another follows various, and often obscure, routes for different victims, and hence may be described as *prosodemic.*

Fifth, that the only remedies for such prosodemic typhoid are absolutely thorough and universal cleanliness, and especially a thorough disinfection of all excreta.

The same conclusions may serve for the present communication, and we propose to reiterate and proclaim them at convenient intervals until the public is aroused and educated to that cleanliness which is next to godliness, and our national excess of typhoid fever ceases to be a discredit to American civilization.

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DISCUSSION.

THE PRESIDENT. The paper is before you for discussion, and I will call first upon Mr. Lochridge.

MR. ELBERT E. LOCHRIDGE.* Mr. President and fellow-members, I have been very glad to hear everything that Professor Sedgwick has said in regard to typhoid, for I believe that in the press and in the general feeling of the majority of the citizens, not only of this state, but of every state and of every city, the opinion prevails that water not only carries typhoid, but that it is the chief carrier of typhoid. I do not want, in any remarks which I may make, to in any way disparage the danger from water-borne typhoid, but the care of water systems, of water supplies, and the general elimination of grossly polluted supplies have really brought about a condition that may be considered as comparative immunity from typhoid epidemics coming from water in many cities.

We have had in Springfield during this past summer — and the situation is not as yet entirely cleared — an epidemic which will bring out this fact very plainly. We have a water supply there of which none of us is proud, and I believe that two thirds of the citizens of Springfield would rather believe something bad of the water than not; so that on the outbreak of an epidemic of typhoid this season, the water was at once blamed.

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* Engineer of Water Board, Springfield, Mass.

Out of the first seventy cases which occurred, I believe the families were supplied with milk by thirty-five different milkmen. This, together with the fact that the number of cases was so small compared with the number of families which were supplied by these milkmen, very effectively removed the milk from the suspicion that it was the carrier of the disease. As a practical water-works man I was extremely interested in the situation, and had all the cases reported to me from the board of health. This was done so that any indication whatever that the water was even slightly to blame could be carefully traced. With the elimination of milk as a possible source, and the general feeling in the city that water was the cause, I undertook to investigate and go thoroughly into the causes of the epidemic. The many statements which have been made that typhoid epidemics are usually due to water or to milk, coupled with the fact that our water supply was not in good repute, was, I believe, responsible for the feeling, not only of suspicion, but of certainty in the minds of most people that the water was to blame.

The local board of health have a routine system of investigation of every case of typhoid. On the cards which they prepare are blanks where may be recorded the usual data, including the source of water supply of the patient, the milk supply, the name of the physician, the date on which the patient went to bed, address before attack, occupation, etc. On looking over the cases one very marked thing stood out at once, and that was the *names* of those who had taken the disease. I followed this up and noticed that the epidemic was confined almost entirely in the earlier stages to residents of one particular section, and that this was the section in which the foreign element lives. Later, as the cases began to multiply, our board of water commissioners instructed me to investigate the epidemic. At about that time Dr. George B. Magrath, now the acting secretary of the State Board of Health, who is present to-day, came to Springfield, and we conducted our investigation along parallel lines.

It was at once seen that the key to the situation was not contained in any of the data which we had, although the data had been rather carefully prepared along the usual lines. It was then determined that the first work should be directed to the securing of more information. Nothing stood out as the cause of the fever from the reports which were in. I mention these facts because

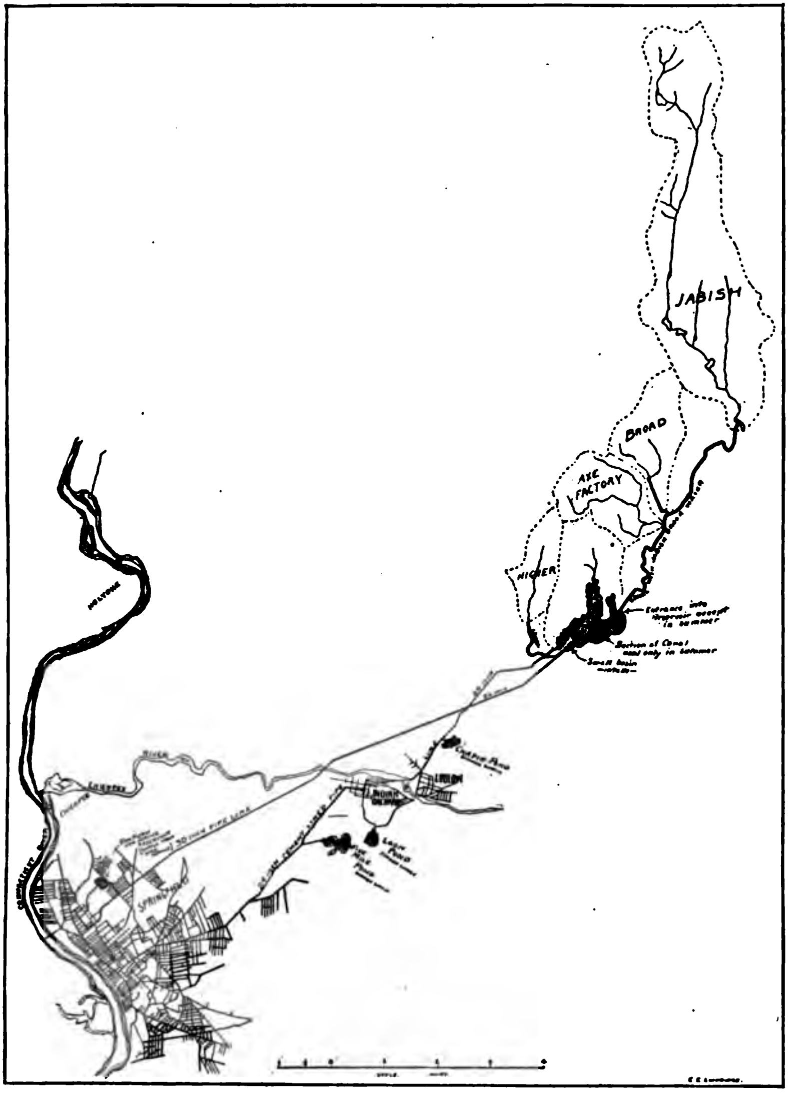

FIG. 1. GENERAL PLAN OF SPRINGFIELD WATER SYSTEM.

as water-works men you may all have to deal with some such epidemic and with some such feeling as we have had, for with the cause of the epidemic very obscure in its earlier stages the general sentiment was in Springfield that the water supply was to blame. This further investigation was conducted along the lines of getting additional information, which was tabulated and worked out independently of the information submitted by the local board of health, and data from each of the sources considered.

I will attempt to give you a brief outline of the situation as it stood at the beginning of this study.

Before you (Fig. 1) is a map of the Springfield water system. Lying to the east of the city proper is the village of Indian Orchard, which is a part of the city. Just beyond Indian Orchard is the village of Ludlow, which has a population of 3 500 people; Indian Orchard has a little less than 5 000. All of Indian Orchard and Ludlow have the same water supply as the city of Springfield. Our Ludlow reservoir is four miles beyond the village of Ludlow, and is practically twelve miles from the Connecticut River. The two mains which we have supplying the city with water pass through these villages to the city, as shown on the map.

To show what our water supply is, I will say that we have a storage reservoir of about 1 800 million gallons, which is fed by several small brooks immediately adjacent to it, and by one that is larger, Jabish Brook, which is diverted through a canal eight miles in length to the reservoir. These are shown on the map. In the summer season the water in the reservoir becomes absolutely undrinkable. It would be impossible to make the people drink it if you gave it to them; they would drink anything else they could get. So in the summer time Jabish Brook is diverted around the reservoir to a small basin containing not over three days' supply.

We have also, east of the city and near the villages of Indian Orchard and Ludlow, three ponds which are situated in a sandy plain and are without tributaries of any nature. These are used only in the summer and for the purpose of making up the deficiency in the amount necessary to supply the city over the summer flow of Jabish Brook. One of these ponds (Five Mile) lies between Springfield and Indian Orchard. The largest amount of water is taken from this pond. The second (Loon Pond) lies just at the village of Indian Orchard, and the third (Chapin Pond) between the Ludlow reservoir and the village of Ludlow.

After about the first of August every summer our supply consists of the direct flow of Jabish Brook, unstored, supplemented by water pumped from the three ponds just mentioned. Between the Ludlow reservoir, which is at sufficient elevation to supply water to the city by gravity, and the city are two mains. All of the water from the ponds is pumped directly into one main at points which can be easily seen by reference to the diagram. This main is the one which supplies, in large part, these outlying villages.

The typhoid epidemic, or the first number of cases with which we had to deal and which are marked in heavy dots surrounded by circles on the map (Plate I), came down in the ten days following the 15th of July. If you will notice the larger number of them, near the west edge of the map, you will see they were confined, with four exceptions, to one district, and this is the foreign district of which I spoke. At that time it became necessary to use the summer supplies. Owing to the nature of the system, all of the hill section, all of Indian Orchard and Ludlow, are supplied by the water pumped from the ponds, which constitutes about 65 per cent. of our supply after that date. The north end, extending to the Chicopee line, is supplied from the other main which comes into the city on Carew Street and supplies all of the down-town district. There is also a low-service system, water for which comes from this Carew Street high-service main, and this service supplies in parallel pipes the district lying near the river, and in general the same down-town district supplied by the main pipe just described.

With the increase in the flow of Jabish Brook following the midsummer rains, the pond supplies were shut off, and at such times the water supplied to all of the hill and Indian Orchard districts was again unstored brook water. Following the dates of such change, which involved a complete change in the source of water furnished these districts, there was absolutely no change in the typhoid situation. We had, then, a knowledge of just which parts of the city were supplied with each of the different kinds of water and the dates on which they were thus supplied. You will then see we had five different sources of supply during this time, and with the knowledge of the dates of each, had any one of the supplies been infected we would have known the locality in which to look for the infection; or on the disease breaking out in a given locality, we could look to a particular source supplying that locality on that date. We found, however, that there was no such comparison. Part of the cases were on the high-service and part of them on the low. The distribution of the earlier cases was not a general distribution which you would get from a water-borne infection, but a distribution on a few streets where the general sanitary conditions were the worst existing anywhere in the city.

Later, the cases which are indicated on the map in heavy dots came down. This map is complete to September 20. If the cases since that date should be added we would have half as many more, confined largely to the same locality, but with some scattering.

The data which we collected were tabulated and we were able to determine with greater accuracy the true date of onset of the disease, that is, the earliest date which it was possible to find that a person had been sick.

A great many patients will be what are called "walking" cases, — patients who will not go to bed for three or four weeks; and we found, as far as the tracing of the time was concerned, that the date of going to bed, which was supplied by the local board, was of very little value.

I am not going into the modes of transmission of this disease in Springfield except very briefly, as Dr. Magrath will cover that in a few minutes, but I want to call attention to this diagram (Fig. 2), which brings out the dates on which, according to our revised data, the epidemic was made manifest, that is, the date of onset.

The earlier cases with which we had to deal were in July, at a time when we were using stored water from our main reservoir. On the earliest date there was a case on the hill (No. 4), which in locality would be right to throw suspicion on the pond supplies, but inasmuch as the epidemic was well started before the pond

supplies were used, and also as the water supply changes already referred to did not affect the distribution of the cases, it could be seen that water could not be considered as a cause. Every possible suspicion which in any way could be thrown on the water was studied, but all additional data pointed away from water and to other causes.

The study made of the individual cases brought out a peculiar fact as far as locality was concerned. With one exception, in all of the earlier cases, I believe the rent paid for the house in which there was a typhoid patient did not exceed $12 a month, and in a great many of them the rent was from $5 to $6 a month, this bringing out the nature of the locality in which the disease broke out. The streets from the railroad through to about Congress Street are filled with a foreign population, principally Russian Jews, Syrians, Irish, and some Italians, while Water Street and the adjoining region is largely Italian. The first cases were largely confined to this class of people, and as the people could not talk English in most of the cases, we had the hardest kind of a time getting any information.

We found that in this earlier group, practically all of them had

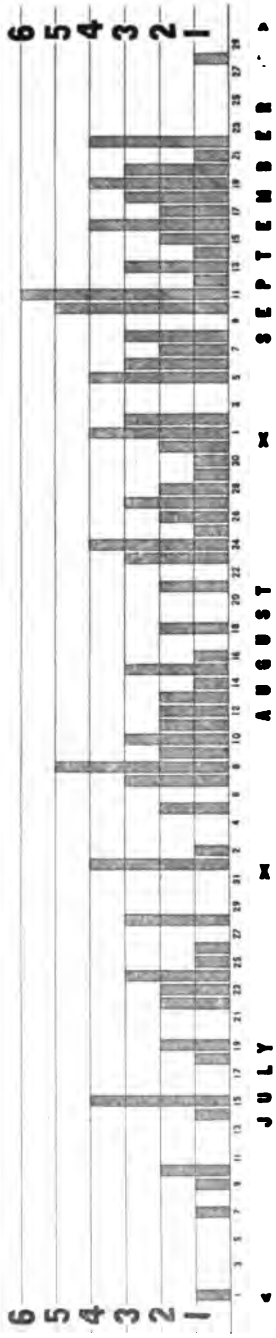

FIG. 2. DIAGRAM SHOWING OCCURENCE OF TYPHOID FEVER CASES IN SPRINGFIELD, JULY–SEPTEMBER, 1905.

gotten their vegetables from one man. Just what the infection of his vegetables was it would be very hard to say. His wife was sick with a slow fever, but with no indication, as far as the doctor's diagnosis was concerned, that it was typhoid. There were at least three cases of typhoid on his route. Then we traced the method of handling the vegetables. He went about in an open wagon carrying vegetables which he purchased both from large dealers and also picked up from farmers, — in any place where he could get them cheap, — and the handling of the vegetables by customers and putting them back on the wagon was found to be the universal practice everywhere in the streets in which he dealt.

From that point on the epidemic took on another nature, and we have called it a contact epidemic. This same vegetable man probably did not cause more than these first cases, but the families in which these first cases came were peddlers, men who passed through the city vending meats, vegetables, fruits, etc., and men who ran small stands.

In taking up the technique of the investigation, I think it would be well to tell how we studied it, for if any of you are so situated that you can get no help at all from your local board of health, you may want to have some means of procedure. If the local board will simply make a statement that your water supply is to blame and let it rest at that, you may want to know how to get at the situation. Three men who understood the nature of the transmission of typhoid were brought to Springfield, and worked under Dr. Magrath's and my direction, Messrs. R. E. Tarbett, W. H. Lalley, and H. C. McRae. They worked faithfully and hard and their assistance was an important factor in finding the cause of the epidemic. These men went from house to house and took note of all the conditions; and the conditions which they found were a good deal worse, and might be described even more vividly, than some of the descriptions which were given in Professor Sedgwick's paper. The uncleanliness of that region was very manifest. In the shops where buns were for sale we found them so covered with flies that you would have to brush the flies away to see whether they were buns or whether they were bananas; and the general method of handling what was exposed for sale was extremely dirty. I must not tell more than that, for Dr. Magrath will give you a number of instances. In general, it can be said that it was a filth epidemic; the seed was planted on very fertile ground.

If we go back into the study of typhoid, we shall find that at one time it was believed that piles of filth bred disease, the typhoid germs multiplying and growing in the piles of filth. Later, when we began to know something more of the germ theory, that all passed away and there was a reaction, and it was said that filth did not cause disease; no matter how much dirt there was, it was not disease and could not cause disease. I think now we are ready to go almost back to the older theory. It is true that germs do not originate in these piles of filth, but they are pretty much at home there, and if they are handled and brought into contact with food or with drink, you will get typhoid from them.

The later stages of the epidemic raised points which in the popular mind were the hardest thing to understand. After about a month or six weeks, we found the disease beginning to get into the better families and spreading out over the city. The better class of people objected to having it said that the epidemic was caused by peddlers, claiming that they did not patronize them, and did not care to have any connection with them mentioned. Even a casual glance at the epidemic, however, brought out an important fact. In the earlier stage the carrying of the infection was probably in that manner. In the second stage not only in this manner, but also in many other means of contact, and in the later stages the means of furtherance could be counted by the dozen instead of by a single one as in the earlier cases. Few families know the history of all of the fruit, vegetables, and other food brought to their homes, or the movements of their servants when not on duty in the house.

With regard to the village of Ludlow it may be well to say a word. Ludlow is a manufacturing town, with a population largely, almost entirely, foreign. In this town through the entire summer there was not a single case of typhoid fever anywhere on the mains, and at the present time I believe there are but three cases in the village, and two of those are entirely off the water supply. Indian Orchard was also exempt. I mention this merely as a confirmation of the general statements which I am making in regard to the transmission of the disease.

And another very marked thing was that these localities were not localities where local or small filters were used. That is a point which is brought up at once. It was given as a reason that a certain class of people were exempt, that they filtered the water, or that they didn't use the city water; but here was a region with a population of over 8 000 who did not have filters in their houses.

Taking up the better localities, you can see at the eastern edge of the map that the so-called McKnight district was practically exempt. The Forest Park district, which is also occupied by the better class of residents, in the southwest corner of the map, was entirely exempt, and in the northern section, the Brightwood district, which is occupied largely by the better laboring class, I believe there was only one case of typhoid fever. These localities represent very diverse water-supply conditions during the period of the epidemic. The region nearest the water supply, which should, in the case of a water-borne epidemic, be first to show its effect, was entirely exempt. The region most directly supplied steadily by Jabish Brook water was entirely exempt. Two other regions supplied alternately by pond water and Jabish Brook water were entirely exempt, while the remaining portion of the city, representing no new sources or no different sources, have in them a large number of cases. So on the face of it you would say at once that it was very simple; but when you come to face the actual situation of a general belief that it is the water, and an unshakable belief on the part of the physicians that it is the water, you have to go into it pretty thoroughly in order to show that it was not. However, we did not go into it to show that it was not the water, but to find out the real cause.

Referring again to the diagram, you will notice the almost intermittent action; that is, days on which the typhoid breaks out, then will follow a lull, to be followed by another outbreak. No two of these groups of cases were supplied by the same water, nor had the same water conditions. You will note that they followed pretty closely the incubation period; that is, each period of cases made new foci and from these foci developed further cases of typhoid, so if we were seeking a cause we should seek a cause for each one of those outbreaks. And that can be seen if you go into the occupations of the first group and follow it right through from group to group.

In regard to seasonal or residual typhoid which has been mentioned, I want to say a word, and that is this: With the elimination of water-borne typhoid we still have this residual or seasonal typhoid. Every city has it, and there is a cause for it and it is a perfectly natural cause; that is, the germ must come from a typhoid patient and must be taken into the alimentary canal of some other person. That is all that is necessary for typhoid, and in all of this residual or seasonal typhoid, every one of the patients must have gotten the typhoid in that way. I believe that this epidemic at Springfield can very clearly be shown not to have been caused by water, but to have been caused by contact in various ways, and I think that in this epidemic we have a magnification of the cause which brings about seasonal typhoid. It was on a large scale, — there were altogether, I think, two hundred cases. Those cases were from the causes which are active each year in producing seasonal typhoid, but inasmuch as the disease was first planted in a district which supplies food for other districts, and in a district which is very dirty, we have the ideal conditions for a very large seasonal typhoid.

Dr. George Burgess Magrath.[*] Mr. President and members of the Association, I wish to thank you most heartily for your hospitality, and for the privilege of listening to the paper of the afternoon and of participating to some slight degree in the discussion of a theme which is of such great interest alike to the sanitary engineer, the biologist, and the physician. Professor Sedgwick has covered the general subject so exhaustively that there is very little which I could possibly add so far as the general aspects of this important problem are concerned; and in what I have to say I shall deal mostly with certain aspects of the epidemic of this year in Springfield, concerning which Mr. Lochridge has told you a great deal.

You will, perhaps, bear with me, however, if I preface what I have to say by some general considerations with regard to acute infectious diseases.

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No department of medical and biological science has shown a greater increase in the sum of knowledge in recent times than that of epidemiology, or of our knowledge of the cause of diseases. The application of this increase of knowledge to sanitary science and for the protection of public health has been most prompt and, as you all know, is of the greatest importance to-day in the protection of our communities from the spread of acute infectious diseases.

If one were asked what is meant by an acute infectious disease, what is meant by a contagious disease, I think he would have to answer somewhat as follows: That by an acute infectious disease we mean one the cause of which is a micro-organism, whether animal or vegetable it matters not, which enters man or the lower animals as a parasite, and, growing, produces in the course of its growth, injurious substances of one sort or another. These poisonous substances cause abnormal anatomical conditions, the outward expressions of which are the symptoms of disease.

Now among the infectious diseases, the germ diseases, — and, of course, our whole conception of the nature of those diseases has been modified within less than a generation by the discovery of micro-organisms, and the identification in many of the infectious diseases of some form of organism which is specifically present in each, in many instances producing changes characteristic of the disease, — among this large group, there are certain diseases which are more easily communicable than others, which are much more easily transferred from one individual to another, than are other diseases; and these are commonly known as the contagious diseases, although there is not necessarily any sharp line dividing one group from the other. Professor Sedgwick has pointed out that typhoid fever under certain conditions is so easily communicable, or is communicated so directly, as to be rated as a contagious disease. But if we contrast with typhoid fever smallpox, scarlet fever, measles,—possibly, also, diphtheria, —we see at once that there are certain diseases which are so easily acquired that it is necessary only to enter the room in which is a patient suffering from one of those diseases, in order to render a susceptible individual, one who has not had the disease or is not otherwise protected from it, extremely likely to catch it.

Now, the first diseases mentioned, *i. e.*, scarlet fever, smallpox, and measles, for a long time, although carefully studied, presented no etiological factor clearly demonstrable, — that is, no definite germ was found in the lesions produced in the course of those diseases. Latterly, there have been recognized, certainly in scarlet fever and smallpox, bodies which belong not to the bacterial group or vegetable group of parasites, but to the animal, and these bodies are capable of producing spores, minute protoplasmic particles, which are easily passed about in the air and communicated or transmitted from one individual to another by the very air that we breathe. That seems to explain why in certain diseases transference from one to another is so easy. Of course, among the bacteria there are those which are more readily killed by sunlight and by exposure to degrees of temperature unfavorable to their development or growth than are others; so that amongst the bacterial diseases there are some which are more easily communicated from one individual to another than are others. In addition to these differences, partly the inherent characteristics of the organism, partly its ability to live under unfavorable conditions, there is the set of differences which obtain according to the way in which the disease is acquired. An organism which, in order to produce its lesions, must be taken into the mouth or nose and into the lungs, is an organism which may be, and is likely to be, one which can be transmitted by the air in dust, and will produce a disease which is easily communicable. That is, there are differences in the way in which these parasites or germs enter the body. Those which enter through the mouth, through the lungs, through the respiratory system, produce diseases which are readily acquired. Those which enter the body through the digestive tract, on the other hand, of which cholera, dysentery, and typhoid fever are examples, are diseases which are not acquired by mere proximity, or by the inhaling of the air which has been breathed by an individual suffering from them, as are smallpox and scarlet fever.

There is still another group of diseases in which the organism must enter through the skin, through the sting of an insect, of which malaria and yellow fever are examples.

Now with the increase of knowledge in regard to typhoid fever, it has become apparent that there are modes of transmission or vehicles for the entrance of the organism into the body (and it must enter through the mouth and be swallowed in order to produce its effects) other than those which for a long time have been recognized as the more prominent, *i. e.*, water, milk, and shell-fish. In other words, it is, perhaps, necessary that we hold in suspicion every article which may be put into the mouth. Such a vehicle may be fruit or vegetables or bread or candy; anything, really, which may pass the lips must be looked upon as a possible conveyence or vehicle for contagion, bearing in mind, of course, that typhoid bacilli will not withstand conditions markedly unfavorable in point of dryness and temperature, as will some of the other forms of parasites, those which produce the spores and are transmissible by the air and dust.

Passing rapidly from such general considerations to the specific instance of this epidemic, Mr. Lochridge has explained to you why, after a careful review of the situation, it seemed improbable that all the cases of typhoid fever in this outbreak should be referable to the water supply. There remained, after you subtracted from the total number of cases those which could be referred to the seasonal or "residual" occurrence, a very considerable number of cases, in fact a very large percentage, which we found distributed focally. Mr. Lochridge has pointed out to you that the distribution of the cases over the city is of some sociological significance.

Upon this map, Plate I, are indicated in dots surrounded by circles cases which occurred during the last two weeks of July. From the 15th to the 28th of July there were some sixteen cases. These sixteen cases had the geographical distribution indicated. It is apparent at once that they are most numerous in the regions which Mr. Lochridge has described as being those occupied by a foreign population, largely by Jews, Syrians, Greeks, and some Italians. This peculiarity of distribution of the early cases, which was continued as time went on and the cases increased in number, this increase taking place in localities where the dwellings were shabby and the rate of rent low, led us to inquire more closely into the domestic conditions, the personal habits, and the physical surroundings of the people living in these localities.

It would be difficult to describe with accuracy and sufficiently forcibly the conditions which prevailed in the Jewish quarters. I have never seen any more marked exhibition of uncleanliness, not to say filth, than prevailed in those quarters. The people were very closely crowded in the houses, and they were very careless with regard to the disposition of their excrement. Open privy vaults to the number of forty were found on two of these streets, but the inhabitants didn't always take the trouble to use the vaults. There were many children in this district, and, of necessity, in accordance with their standard of living and decency, the distribution of excrement was rather widespread. To a certain extent the same conditions prevailed in all of the regions where typhoid fever was most prevalent. These seem to be the remains of Old Springfield. Tucked away in behind the higher and better buildings, old houses, poorly constructed, poorly equipped, and with imperfect plumbing or no plumbing at all, still exist. In one of these regions a number of negroes live, and in another region there is a "poor white" class. Along Water Street are many Italians, and in the progress of the epidemic many more cases developed in this district than are shown upon the map.

The elimination of water and milk as vehicles of contagion, rendered possible by careful study of all the conditions, showed that we must inevitably be dealing here with other means of infection, some of which Professor Sedgwick has referred to this afternoon. First of all, within the families opportunity existed for contact spread of the disease. There is no question about it. Given one case in a family of seven or eight individuals living in three rooms, with conditions of extreme filth in the kitchens and living rooms, with no precaution whatever taken to prevent contamination of food by filth, it seems to me that conditions were ideal for contact spread. But that would not, of necessity, relate cases in the dirtier districts with cases occurring elsewhere in a population comparable with that in such regions.

The incidence of these cases in point of time, the fact that there occurred in all of this region in the last two weeks of July and first two weeks of August cases of typhoid fever, led us further to inquire whether there was any vehicle which possibly could be operative in these different communities at the same time or nearly the same time. We were continually impressed with the fact that it was among the poorer people and the dirtier people that the disease was spreading, and, of course, there was the possibility of contact spread elsewhere. I think it is undoubtedly true that typhoid fever had existed here from early in the spring, that cases which nearly overlapped in point of time existed in this region, and one, at least, existed in this region as early as April, and that case had access to, and used, an open privy vault, the contents of which were not removed. The houses in the vicinity were all poor shacks, with unscreened and broken windows, and, if we are entitled to admit in the spread focally of typhoid in these regions the possible instrumentality of flies, there certainly existed the opportunity.

In this connection it is worth mentioning — and this was the result of rather a careful study of the region from day to day — that in this quarter are venders of all sorts, bakers, green grocers, and dispensers of fruit in hand-carts, whose routes take them in and out through these streets, off along through the Italian quarter, and to some extent up through State Street and over through Walnut Street, and down into the part of the town known as the Watershops district. It was perfectly manifest to us that venders of various sorts, selling through this region where most of the cases occurred, in the earlier part of the summer, also did business in the parts of the town where typhoid subsequently became rather prevalent. The machinery existed for the conveyance of the disease in that fashion to some extent. Whether that really was a factor is, of course, bound to be a matter of some speculation. There is no direct evidence; it is all circumstantial evidence at best, but the way in which these hucksters sold their goods certainly impressed upon us the fact of the possibility of this mode of spread. The vender of fruit and vegetables starting in here in the morning (he might or might not be a resident of that quarter, although three or four peddlers of that sort did live in that quarter), starting in on one of these streets, would go from house to house; the women would come out and overhaul the stock and select what they wanted and purchase it, and the wagon would go on to the next house. Now there was enough typhoid in and out through those streets to have rendered it certainly possible, if not probable, bearing in mind always the habits of the people, the fact of personal uncleanliness, the fact of a considerable prevalence of typhoid among children, many of them infants, that contact infection should take place; that is, for the direct passage of infected filth from hands to these wares to have occurred. Furthermore, all through these streets are small basement shops in which are exposed for sale, as Mr. Lochridge has stated, bread, cake, pastry, and green stuff. At the time of the year when I was in Springfield the latter consisted mostly of apples and, to some extent, peaches and pears, cabbages, and so on. In the earlier part of the summer, of course, there were lettuce and berries of various sorts. The wares in these shops were handled in very much the same fashion as those in the peddlers' carts, that is, people who were going to purchase would overhaul the stock and select what they wanted. This as a medium for local spread I regard as of some importance, and the venders as of importance, also, in the spread of the disease from one neighborhood to another. The people living here are of such sort as to render them patrons of the small venders with push-carts, which is not true of the inhabitants of other districts. These carts are not to be found up in the McKnight district, or in the Forest Park district.

One other point. The Hampden County jail is situated here (Cases 8, 23, 24, 102, 103, and 116), and in the first two weeks of what we may speak of as the epidemic, which period coincides with the last half of July, there occurred one case of typhoid fever, and within a week of that time two others in the jail, all on the same cell tier and on the same side of the cell stack. This occurrence of the disease in a population which was largely immobile, the three cases which I refer to occurring amongst long-term men, — no one of them had been in the jail less than four months, and the most of them were there for a two years' sentence, — seemed to offer a somewhat anomalous fact. Cases subsequently occurred to the number of six, all among men who had been in the jail for six months at least, and some of them for a year or more.

Now, how did the disease get there? The jail is an exceedingly well-governed institution. It is exceedingly clean, one of the best medical men in Springfield is the attending physician, and I have never visited an institution of its sort where the sanitary conditions were of any higher order than they are in the Hampden County jail. The fact, however, must be recognized that prisoners have ways and means of getting certain things that they are not supposed to get. They are allowed in the Hampden County jail chewing gum and cough drops. Tobacco is not allowed, but tobacco does find its way into the Hampden County jail, as I guess it does into every reformatory institution. Some of the short-term men, men in for a few days, are employed on the outside of the building, around the jail grounds, taking care of the premises, and they were in the habit after raking up the ground of taking the débris of various sorts over to the city dump, which lies at a distance of about one hundred yards easterly from the jail. Incidentally they would look over the débris and bring back cigar butts, and, probably, anything else which they thought worth taking away, and which could be put into their pockets. This statement as to their bringing back cigar butts is on the testimony of at least three men who had typhoid fever and were taken to the hospital. I do not offer this as an explanation of typhoid fever in the jail, but I do think that jail walls are not strictly impervious, and that something which might act as a vehicle for the transmission of typhoid could have found its way into the jail. We don't know anything about it, and I merely mention it as an anomaly in this epidemic. Of course, there is an explanation for it, and I think it may be along the lines which I have intimated.

All of this, it seems to me, goes to show that there can occur in our cities epidemics of typhoid fever which are not attributable to the water supply, or to milk, but which occur because, as Mr. Lochridge has stated, inflammable material or a fertile soil exists upon which infection will thrive if it happens to get planted. It became so planted in Springfield, and upon a soil favorable to its spread. The fact that typhoid fever had not spread in these regions before is no objection to this as an explanation. A part of a city in which the buildings are far below, we will say, the requirements of modern building laws, is a permanent menace to the city from danger of fire so long as it is there. The regions of the city of Springfield in which the epidemic thrived are those in which the sanitary conditions were the poorest, where the advance of civilization and sanitary improvement had not gone far enough to eliminate the privy and to render imperative such improved conditions within the houses as would have removed from the city the soil upon which the epidemic spread.

Prof. C.-E. A. Winslow. We may well be proud of the leadership of Massachusetts in sanitary matters and especially in the matter of water supplies. I think it may be said that a man can go to almost every city and town in Massachusetts and drink from the public water supply with safety, which certainly cannot be said of any other state in the Union. That having been accomplished, however, we cannot afford to remain satisfied with our laurels. We must move onward, and having wiped out here the highest death-rates from typhoid fever, ranging from 25 to 125 per 100 000 in cities having polluted waters, it becomes us to turn our attention particularly to the residual typhoid, the 15 to 25 deaths remaining, and to endeavor to find out what causes that.

We have had a splendid object lesson as to residual typhoid in this Springfield epidemic. It has been shown most conclusively, I think, by Mr. Lochridge and by Dr. Magrath, that the Springfield epidemic is not due to water. Of course, in studying the cause of any phenomenon it is always easier to fall back on the cause of other similar phenomena, than to try to find out a new one actually operative in the particular case. It was easy enough, and perhaps right enough, twenty years ago, to say that typhoid fever was due to the water supply, but that explanation will not serve in many communities to-day.

When we find, as we do on an inspection of the typhoid death-rates, that we still have 15, 20, or 25 deaths from typhoid per 100 000 of population, and when we look abroad and find that in England and in Germany they have death-rates from typhoid ranging perhaps from 3 to 10 per 100 000, it is time that we asked ourselves the reason. If, as has been brought out in the paper and the discussions this afternoon, typhoid is essentially a filth disease, a disease which is carried by excreta getting where excreta should not be, it is obvious that we must ask ourselves whether we are a dirty people, whether we are a dirtier people than the Germans and the English.

Of course we have in our cities to-day an extremely difficult problem to meet. We haven't an essentially American population, — a Yankee population, — but we have a population including groups of Greeks and Syrians and Armenians and Italians, people from the south of Europe who have come from unsanitary conditions and who are accustomed to unsanitary conditions.

One of the points which has greatly interested me in the history of the Springfield epidemic has been the comparison of the typhoid fever rate with the social condition of the population. It is a new thing, I think, to connect a typhoid epidemic with low rents, but it appears to have been justly done in this case. That is, the typhoid epidemic is there because of the dirty surroundings which accompany low rents. To be sure we do not have typhoid epidemics everywhere where there is filth, and that argument will always be brought up in a discussion of this sort. But, as the gentlemen who have spoken have said, filth is the inflammable material. It does not explode until the match is applied to it. But it is so fatally easy to apply the match, so fatally easy to introduce the one case of typhoid fever which will spread like fire through the filthy region, that we must regard the filth as always a potential agent in the transmission of typhoid fever.

Furthermore, that one case need not be a recognized case. We have numerous examples of walking typhoid, cases which, perhaps, are never known as typhoid fever, where the persons may walk about and feel poorly and, perhaps, have a little diarrhea for three or four weeks and then may get well without ever knowing that they have had anything but some little summer trouble; and yet they have had typhoid fever and have been all the time spreading the germs more actively than if they had been actually confined to bed with the disease. We know that typhoid germs may be present in the urine of a typhoid patient after recovery, in some cases for months, so that a person who has become apparently quite well may still be going about sowing the seed. In view of these facts the one thing for us to do is to see to it, so far as we can, that there shall be no accumulation of inflammable filthy material ready to be set aflame at any moment.

Another point which interested me particularly in what Mr. Lochridge said was the spread of the epidemic to the better localities in the city. That will inevitably occur. It is true nowhere more than in sanitary science that we are all members of one body, and that if one part of a city is allowed to be filthy, other parts of the city are sure to suffer. If there is typhoid infection in the dirty part of the city, that will get on clothes or on fruit, or be brought into the best houses by servants who have mothers and brothers and sisters in the slum districts whom they go to see, as I have found in two or three cases of small obscure typhoid epidemics. These servants perhaps go into the filthy districts, where they make the beds of the patients, and then return and prepare the food for the families in luxurious residential districts.

We must not allow these plague spots to exist. If we are to do away with residual typhoid, and lead in that as Massachusetts has led in the elimination of water-borne typhoid, we must take up the question of personal cleanliness. We must educate the people to personal cleanliness, and so far as our city and state boards of health are concerned we must see to it that those powers which exist, and which to-day in the case of our city boards of health are ample to do what need be done, are exercised vigorously and forcibly.

THE PRESIDENT. It seems to me, gentlemen, that the water-works superintendents ought to go home from this meeting feeling pretty happy. Heretofore every time that there has been a typhoid fever epidemic it has always been said that the water has been to blame, and now we have found typhoid fever in pretty large quantities where the water has nothing whatever to do with it. It is now time for the boards of health, which have hitherto told the water-works superintendents to go ahead and do the work, to go ahead and do something themselves. So I think we all have had reason to feel very well satisfied with ourselves in view of what we have heard in this symposium here to-day. I should like to ask Professor Kinnicutt to say a few words.

PROF. LEONARD P. KINNICUTT.* Mr. President, I think this is a little bit rough on me. I am not at all in a pleasant mood. In order to get here I had to go without my lunch, so I am not in that happy frame of mind that I might have been if I had partaken of my lunch here with you. Then, again, in the mail this morning I received the following letter which I didn't open until I entered the train: "*Dear Sir,* — Please review the enclosed typewritten transcript of your remarks, made at the meeting of the Public Health Association, and return the corrected copy to me as soon as possible." I may say that I was called upon there unexpectedly, in the same way as the president has called upon me now, to say a few words regarding "Trade Wastes." I opened this copy, and the first sentence that met my eye was this: "In Worcester there is one very large concern, the American Iron and Steel Company, that use a very large amount of sulphuric acid in pickling their hams. [Laughter.] This iron sheet paper is thrown into the stream and causes great pollution." [Laughter.] I threw the copy aside, and made a solemn vow I would never speak again without being prepared. [Laughter.] I am afraid, however, like most of my good resolutions, it will only last for a short time. [Laughter.]

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* Worcester Polytechnic Institute, Worcester, Mass.

But, really, I have only a very few words to say to-day, and after what I am going to say I am afraid that you may not go home in quite the happy frame of mind your president expected you to. There is no question, as I think it has been very well shown in what has been said here to-day, that typhoid fever is not only a water-borne disease, but a contact disease. Professor Winslow, however, in his remarks suggested one question which I have been asking myself ever since I came into this room, and that is, Why is it that where you have well-cared-for and well-purified water supplies, the typhoid fever rate in Germany is only from 5 to 10 per 100 000, and in this country, as Professor Sedgwick has said, it is between 18 and 25 per 100 000? It cannot be claimed that the Germans are a more cleanly people than we are in this country. In the first place, the water-closet is nowhere nearly as common in Germany as it is here, and the privy is very much more common. Also, in the poorer quarters in the large cities like Berlin and Munich, there are just as bad conditions as are found in our tenement-house districts. They also have the fruit sold on the streets just as we have it sold here, and I imagine that a great deal more fruit is bought on the streets at the little booths than is bought from peddlers in this country.

I think it is a question which we should ask ourselves, then, Why is it that we have in our cities here, which have a good water supply, a higher death-rate from typhoid fever than they do in Germany? Now, I think that one thing should be borne in mind regarding our water supplies. The water supplies of our chief cities in New England, as Professor Sedgwick has said, are generally good, pure water supplies. But let us go into the country; let us go into Vermont; let us go into New Hampshire. I have had occasion during the past two months to look over the returns from the State Board of Health of Vermont, and I have found that of the wells there which have been investigated during the past year, one-half contain polluted waters; and I mean by polluted waters, waters which receive sewage drainage. I think possibly that may account for a certain increase in our typhoid death-rate even in cities where we do have good sanitary water supplies. I am one of Professor Sedgwick's pupils, and I hate to make any statement in his presence, so I will merely ask the question: What would the effect be upon the typhoid fever death-rate in our cities if we could in any way obtain a perfect water supply all through the country?

MR. FREEMAN C. COFFIN.* Mr. President, it is very interesting for us to learn that typhoid fever which is not caused by a defective water supply is caused by low rents. That may be very pleasing to us, but I hope that the reporters will omit to mention the fact, because we all know that the landlords are an altruistic set of people and I am afraid that they would raise their rents immediately. (Laughter.)

THE PRESIDENT. Will Dr. Hollis say something?

DR. FREDERICK S. HOLLIS.† Mr. President and gentlemen, I came without preparation or thought of having anything to say, and must confine my remarks to tests which I have made from wells in different towns in Connecticut, particularly those used to some extent by the public, samples from a great many of which were received from the health authorities of the various towns.

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* Civil Engineer, Boston, Mass.

† Tufts Medical School, Boston, Mass.

Many of these were found to be highly polluted, as was shown by the presence of bacillus coli; and I have no doubt that many of these wells, the water from which is not infrequently used in preference to that of the public supply, are, as Mr. Weston has said of many springs, sources of infection.

I have felt that this branch of work, the study of samples taken at the discretion of the local health authorities from semi-public wells, is very important.

Of the seventy-two wells examined during two years, the majority of which were of this character and under suspicion, thirty-two gave positive tests for bacillus coli, seven gave doubtful results and thirty-three gave results that were negative.

THE PRESIDENT. Mr. Locke, we should like to hear from you.

MR. WILLIAM W. LOCKE. I haven't a great deal to add, Mr. President, to what has already been said. While traveling up and down the Metropolitan watersheds I have occasionally found isolated cases of typhoid fever which probably came from polluted wells; in most cases that seems to be the indication. We do our best to prevent the spread of the disease to other individuals or localities, and I think the records show that not many cases of that kind come to Boston. In connection with a recent suit for damages, one of the commissioners made the statement that he had been told by a sanitary expert that typhoid fever came from other sources than from human beings, that is, that animals propagated the disease, and it was spread through animals. I should like to ask the question of the experts here to-day whether there has ever been a well authenticated case where typhoid has come through animals.

PROFESSOR SEDGWICK. I never heard of any.

ELECTRIC PUMPING AT SCHENECTADY, N. Y.

BY G. S. HOOK, CIVIL ENGINEER, SCHENECTADY, N. Y.

[*Presented September 14, 1905.*]

Wherever cheap power is available, it would appear that an electrically driven municipal pumping plant should offer many advantages well worth considering, both by water-works superintendents and fire protection engineers. Nor can electric pumping now be considered merely experimental, for since October, 1904, the city of Schenectady, N. Y., has received its entire water supply by this method, and Buffalo, N. Y., has been using electric power for a like purpose. The letting of contracts for the electrical equipment of pumping stations for the New York high-pressure fire supply in both Manhattan and Brooklyn boroughs also indicates that the compactness, simplicity, and prompt service of the electric motor, when applied to emergency pumps of large capacity, is now being recognized by insurance engineers and underwriters.

As Schenectady has been the pioneer in the use of electric power for a high-pressure municipal water supply, a description of the plant now in continuous operation there should naturally find a place in the literature of this important subject.

The new electric pumping plant of the Schenectady Water Works is located at Rotterdam, N. Y., about three miles west of Schenectady, adjacent to the old plant, which is equipped with two vertical steam pumps of 6 000 000 gallons daily capacity each.

Plate I, Fig. 1, is an exterior view of the steam and electric pumping stations, and gives a good comparison of the sizes of the two plants. The small building at the left, solidly built of brick and steel, is the new electric station. Its rated capacity is 24 000 000 gallons in twenty-four hours, against a head of 110 pounds per square inch — twice the output of the old steam plant — and it occupies a very much smaller ground space.

The pumps are 18-inch two-stage vertical shaft turbine type, built by Henry R. Worthington. They consist of an outer casing, inside which is located a set of fixed diffusion rings and vanes, and a rotating runner or "impeller." The water enters the top of the casing at the center of the impeller, and is thrown out through the diffusion vanes into the discharge chamber. The vanes are so curved as to transform the kinetic energy, imparted to the water by the pump, into static pressure with minimum loss. The pumps are installed in the 21-foot pit of the station, as shown in Plate I, Fig. 2, and Plate III, and draw the water through a 42-inch suction pipe from two circular wells 42 feet and 35 feet deep and 50 feet in diameter. These wells are near the electric pumping station building and are covered by a steel-reinforced concrete structure. They have 3-foot concrete walls and gravel bottoms, up through which the water filters. One of the wells is to be seen in the foreground of Plate I, Fig. 1.

The vertical shafts of the two main pumps extend to the station floor and are direct-coupled to the rotors of two 800 horse-power (rated), 550-volt, 40-cycle, three-phase General Electric squirrel-cage induction motors, installed on the station floor (Plate I, Fig. 2, and Plates II and III). The rated speed of the motors is 800 revolutions per minute, and their lubrication, a very important matter at such high speed, is effected by forcing oil, at a pressure of about 100 pounds, under the thrust bearing, which is arranged in the horizontal bearing shield on top of the motor. For supplying the oil, two vertical triplex Knowles oil pumps, each direct-driven by a geared 3 horse-power induction motor, are provided. Since the main pumps are located above the normal water level of the wells, a two-cylinder, 9-inch × 7-inch vacuum pump, direct driven by a 5 horse-power induction motor, is installed on the station floor and used to produce a vacuum in the suction pipe so as to draw the water to the pumps when starting up. A drainage pump of the Worthington one-stage vertical volute type is installed in the pit. Its vertical shaft extends like that of the main pumps to the station floor, and it is driven at 1 200 revolutions per minute by a direct connected, 5 horse-power, three-phase induction motor installed near the priming pump, as shown in Plate I, Fig. 2, and Plate III. All of the motors are supplied with 550-volt, 40-cycle, three-phase current, and have squirrel-cage rotors.

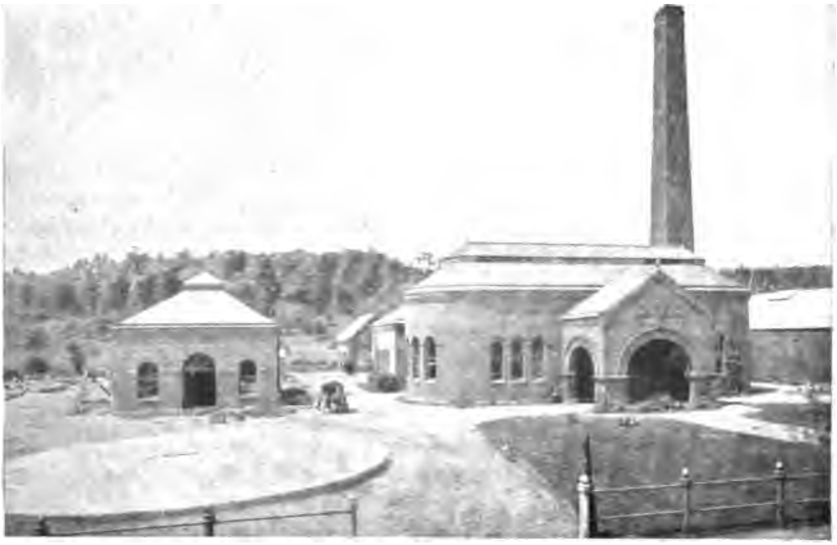


FIG. 1. SCHENECTADY WATER WORKS PUMPING STATIONS, ROTTERDAM, N. Y.

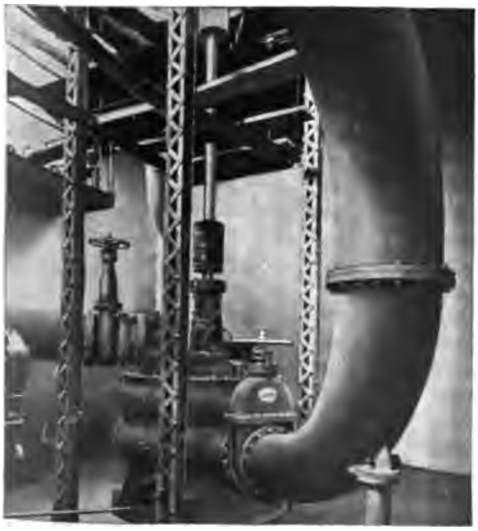


FIG. 2. ONE OF THE 12 000 000 GALLON INDUCTION MOTOR DRIVEN PUMPS, ROTTERDAM PUMPING STATION.

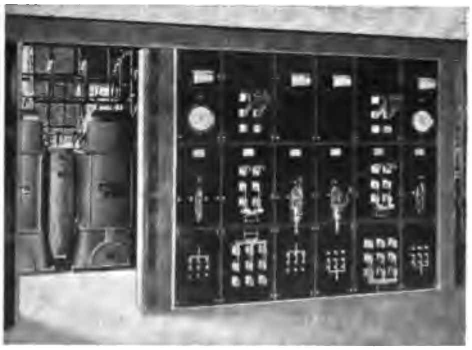
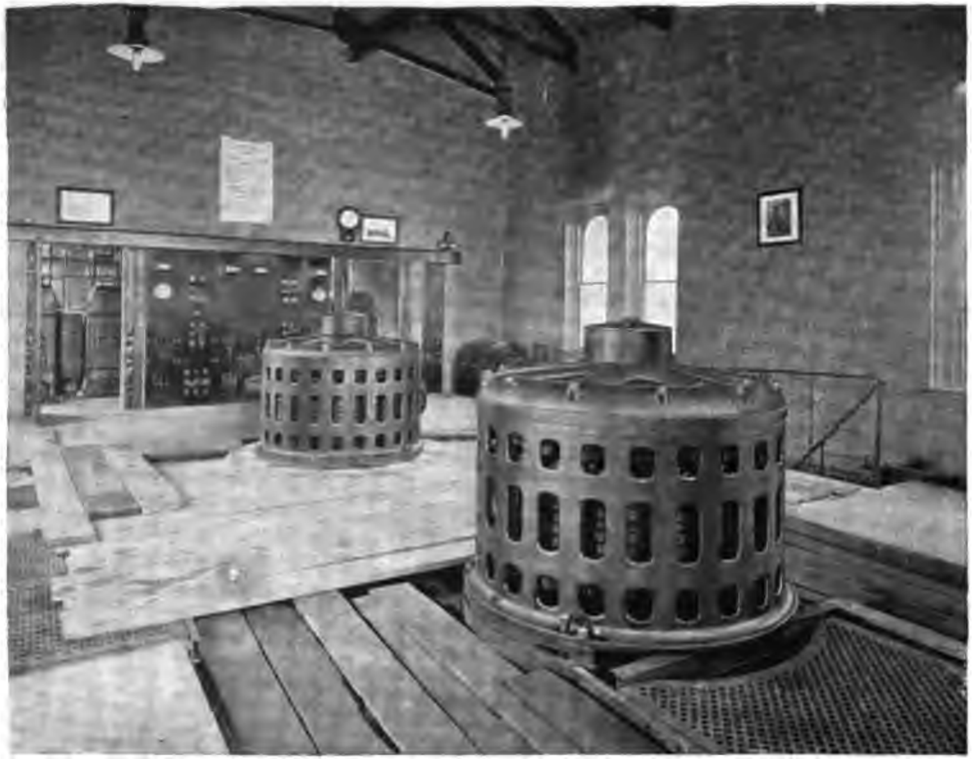


FIG. 3. ROTTERDAM PUMPING STATION SWITCHBOARD, BUILT INTO THE PARTITION BETWEEN THE MOTOR AND TRANSFORMER ROOMS.

PLATE II.



Interior of the Rotterdam Pumping Station, Schenectady Water Works, Showing the Two 800 Horse-Power Vertical Shaft Induction Motors for Operating the Main Pumps.

Two separate and independent 10 000-volt transmission lines are provided, running from the Dock Street substation of the Schenectady Illuminating Company, which furnishes the city of Schenectady with power, and which receives its current from the water-power station in Mechanicsville and Spiers Falls. The lines are also connected to the power stations of the General Electric Works as a further source of power. The lines are controlled at both ends by General Electric automatic oil switches, and protected at both ends by General Electric lightning arresters. The oil switches are so adjusted that a heavy overload of the pump motors will trip the switches at the pumping station end of the line only, so that the pump service can be resumed immediately by closing these switches. On the other hand, a dangerous overload, or a short circuit on the line, will trip the generating station switches also, thus protecting line and apparatus against injury.

At the pumping station the high-tension current is stepped down to 550 volts by two banks of three 250-kilowatt single-phase air-blast transformers (Plate I, Fig. 3; and Plates II and III). The transformer secondaries are provided with taps, wired to double-throw switches, for starting the 800 horse-power main pump motors at quarter and half voltage in order to avoid the heavy rush of current that would be caused if the motors were started at full voltage. There is also installed a 150-kilowatt, 10 500/9 500-2 400/2 200 volt lighting transformer, which supplies current to the village and the railway station nearby. The necessary air blast is supplied by two independent induction-motor-driven blowers installed on the station floor.

A fireproof partition separates the roomy compartment containing the bus-bars and all of the high-tension apparatus — lightning arresters, disconnecting switches, oil switches, transformers, etc. — from the motor room, and the entrance from one to the other is closed by fireproof doors. Imbedded in and forming part of the partition is the switchboard, containing two incoming line panels, two high-tension transformer panels, and two low-tension main motor panels, equipped with the necessary ammeters, voltmeters, low-tension lever switches for controlling the main pump motors, and handles for the remote control of the high-tension oil switches which are installed in fireproof brick cells. On these panels are also installed the lever switches controlling the auxiliary motors, and the vacuum and water-pressure gages. Plate I, Fig. 3, gives a view of this switchboard, with the transformers, high-tension switches, bus-bars, etc., visible through the open door at the left.

The electrical layout is designed to coöperate with the use of the two independent supply lines in preventing any possibility of a total shutdown of the entire plant, upon the continuous operation of which depends the water supply of the city of Schenectady. Two sets of low-tension busses are provided, and the double-throw switches enable either of the two banks of transformers to be switched on to either one of the two sets of bus-bars. The main and auxiliary switches are also double-throw, to facilitate switching over from one bus to the other.

The turbine centrifugal pump is especially adapted to meet extraordinary demands for a large supply of water. For instance, in the case of a large fire, where a heavy demand for water is made beyond the nominal capacity of the pumps, and a reduction in pressure follows, the turbine centrifugal pump will, under these conditions, deliver a very largely increased amount of water when operating against the reduced pressure.

In the Rotterdam installation the pumps are designed to deliver at the rate of 12 000 000 gallons each per twenty-four hours, against a working pressure of 110 pounds. A further requirement is that with all the outlets from the pumps closed and the pumps and motors running at full rated speed, the pressure shall not exceed 120 pounds per square inch. This requirement is completely fulfilled by these centrifugal pumps, thereby avoiding all liability of the very serious accidents which have occurred to water mains supplied by reciprocating pumping engines and to these engines themselves, when, through either accident or design, the valves or distributing mains have been closed.

The electrically driven turbine pump requires less than half of the space needed for the most compact form of reciprocating steam pumping plant of equal capacity. A comparatively light and inexpensive foundation is required, as there is an entire absence of stresses due to reciprocating motions. The only moving part is the rotor-driven impeller, and there is comparatively little noise or vibration. Little or no expenditure is required for upkeep and repairs, as the only wearing surfaces are the bearings. The attendance and depreciation are, therefore, nominal.

All of the electrical apparatus in this pumping station is of General Electric make. The station has now been in continuous satisfactory operation for nearly a year, and the adjoining steam station, formerly used, has been entirely shut down.

It may be added that the efficient response to several extraordinary demands made upon this system during large fires, when as many as 19 hose streams have been taken from consecutive hydrants, has proved to the insurance interests that these pumps can be speeded up to meet any emergency within the delivering capacity of the mains.

WILLIAM THOMPSON SEDGWICK: PRESIDENT NEW ENGLAND WATER WORKS ASSOCIATION.

BY M. N. BAKER, ASSOCIATE EDITOR, "ENGINEERING NEWS."

*[Reprinted * from "Engineering News" of January 11, 1906.]*

The New England Water Works Association did credit to itself, as well as to Prof. William T. Sedgwick, of the Massachusetts Institute of Technology, by electing the latter as its president on January 10. Professor Sedgwick has long been a stanch supporter of the association and has taken no small part in the development and application of knowledge of pure water supplies, how to get them and how to keep them. He has also contributed largely to other branches of sanitary science, and, as will appear later, has had important connections with municipal and state civil service reform. In view of all the foregoing facts we take pleasure in presenting herewith a biographical sketch and portrait † of this newly elected society president.

William Thompson Sedgwick was born in West Hartford, Conn., on December 29, 1855. He was the son of William and Ann (Thompson) Sedgwick, and a direct descendant of Robert Sedgwick, of Charlestown (Boston), Mass. The latter was born in Woburn, England, in 1611, arrived in Boston in 1636–7, died in Jamaica, W. I., in 1656, after having been sent from Boston by Oliver Cromwell as major-general to command the British forces in Jamaica.

The subject of this sketch prepared for college at the Hartford high school, and in 1877 graduated with the degree of Ph.B. in biology from the Sheffield Scientific School at Yale. After a year as a student of medicine, and a like period as instructor in physiological chemistry, at Yale, Mr. Sedgwick went to Johns Hopkins University. Here he was, successively, fellow, instructor, and associate in biology, from 1879 to 1883, receiving the degree of Ph.D. in 1881. In December, 1881, he was married to Mary Katrine Rice, of New Haven, Conn. In 1883, by invitation of

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* With slight changes.

† See frontispiece. This portrait is from a later photograph than the one printed in *Engineering News.*

Gen. Francis A. Walker, he went to the Massachusetts Institute of Technology as assistant professor of biology, rising to associate professor in 1885, and to the full professorship in 1891, which he has held ever since. In 1902 he was made director of the Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology.

To water-works men and municipal sanitarians Professor Sedgwick made himself widely known during the period from 1888 to 1896, by his services as biologist of the Massachusetts State Board of Health. In this capacity he took an important part in the studies of water and sewage purification at the Lawrence Experiment Station, collaborating with Hiram F. Mills, engineer member of the board, the late Thomas M. Drown, then chemist of the board, and F. P. Stearns, M. Am. Soc. C. E., then chief engineer to the board. It was under the guidance of such men as these, including, of course, Professor Sedgwick, that Messrs. Allen Hazen, George W. Fuller, H. W. Clark, E. O. Jordan, W. R. Copeland, and many other well-known water and sewage engineers, chemists, and bacteriologists had their early training and inspiration.

During his connection with the Massachusetts State Board of Health, Professor Sedgwick made a number of notable studies of water- and milk-borne epidemics of typhoid fever, accounts of which may be found in the annual reports of the board. Just before the Columbian Exposition, Professor Sedgwick published, in conjunction with Mr. Allen Hazen, an exhaustive historical and sanitary study of typhoid fever at Chicago, giving comparisons with New York, Boston, and other cities (see *Engineering News*, April 21, 1902). Later, Professor Sedgwick reported on water supply and typhoid fever at Burlington, Vt. (see JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, March, 1896), and at Pittsburg, Pa. (see "Report of Pittsburg Filtration Commission," 1899). He has contributed a number of papers to the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, one of the most valuable being an "end of the century" address, on "The Rise and Progress of Water Supply Sanitation in the Nineteenth Century,"* read in 1901 before the association which has now chosen him for its president.

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* Vol. 15, p. 315 (June, 1901).

A mere enumeration of the most important official positions held by Professor Sedgwick since 1896, many of which he is still filling, indicates his wide range of interests and public and semipublic services: curator, Lowell Institute, Boston, since 1897; chairman, pauper institutions trustees, city of Boston, 1897–99, and acting institutions registrar, 1899–1900; vice-president, Boston Society of Municipal Officers, 1899–1901; trustee, Simmons College, Boston, since 1899; chairman, American Society of Bacteriologists, 1899, and president, 1900; president, Boston Civil Service Reform Association, 1900, and Massachusetts Civil Service Reform Association, 1901; president, American Society of Naturalists, 1901; president, Board of Directors, Sharon (Mass.) Sanatorium for Consumptives, since 1902; member, Advisory Board Hygienic Laboratory, Public Health and Marine Hospital Service, since 1902; one of the principal experts, Chicago Drainage Canal case, 1903–4; member, Board of Trustees, Faulkner Hospital, Boston, since 1903; member, School Committee, Brookline, Mass., since 1904; vice-president, and chairman Section K (Physiology and Experimental Medicine), American Association for the Advancement of Science, 1904–5.

As a writer or public speaker on his chosen subjects Professor Sedgwick has few equals in clearness, force, grace of expression, and power of holding his readers or hearers. Besides his many official reports, and his addresses and papers before the New England Water Works Association and other organizations, he is the joint author with the distinguished Prof. E. B. Wilson, of Columbia University, of " General Biology " (*American Science Series*, first edition, 1886); assistant editor of the " Life and Letters of William Barton Rogers," founder and first president of the Massachusetts Institute of Technology (1896); and author of the " Principles of Sanitary Science and Public Health " (1902). In collaboration with Professor Hough, formerly his assistant professor, and now of Simmons College, he has in press a novel and original textbook for high schools and colleges, entitled "The Human Mechanism: Its Physiology and Hygiene, and the Sanitation of Its Surroundings."

This sketch would not do full justice to its subject if it failed to mention Professor Sedgwick's notable achievements as a teacher.

Of these it is only necessary to say here that to his high capacity for instruction he joins powers of inspiring his pupils with his own zeal for both conscientious routine work and for original research, and that his pupils are eagerly sought to fill positions demanding a combination of high scientific attainments, a willingness to work, and personal integrity; that is, he turns out men as well as scientists.

PROCEEDINGS.

DECEMBER MEETING.

HOTEL BRUNSWICK,
BOSTON, December 13, 1905.

Mr. George Bowers, President, in the chair.

The following members and guests were present:

MEMBERS.

S. A. Agnew, C. H. Baldwin, F. A. Barbour, G. W. Batchelder, J. F. Bigelow, J. W. Blackmer, George Bowers, E. C. Brooks, J. C. Chase, F. C. Coffin, M. F. Collins, W. R. Conard, F. H. Crandall, A. O. Doane, C. R. Felton, J. N. Ferguson, W. E. Foss, A. N. French, E. V. French, F. L. Fuller, T. C. Gleason, A. S. Glover, J. A. Gould, F. E. Hall, J. C. Hammond, Jr., V. C. Hastings, D. A. Heffernan, H. G. Holden, J. L. Howard, E. W. Kent, Willard Kent, J. W. Killam, F. C. Kimball, G. A. King, F. A. McInnes, D. E. Makepeace, W. E. Maybury, John Mayo, A. S. Merrill, H. A. Miller, F. L. Northrop, J. H. Perkins, Dwight Porter, W. W. Robertson, C. W. Sherman, Sidney Smith, G. H. Snell, J. T. Stevens, W. F. Sullivan, C. N. Taylor, L. A. Taylor, R. J. Thomas, W. H. Vaughn, C. K. Walker, Elbert Wheeler, J. C. Whitney, G. E. Wilde, O. J. Whitney, F. I. Winslow, G. E. Winslow, F. E. Winsor. — 61.

ASSOCIATES.

Ashton Valve Co., by H. H. Ashton and C. W. Houghton; Builders Iron Foundry, by F. N. Connet; Chapman Valve Mfg. Co., by Edw. F. Hughes; Coffin Valve Co., by H. L. Weston; Henry A. Desper; Hersey Mfg. Co., by J. A. Tilden, Albert S. Glover, W. A. Hersey; International Steam Pump Co., by Samuel Harrison; H. Mueller Mfg. Co., by George A. Caldwell; National Meter Co., by C. H. Baldwin and J. G. Lufkin; Perrin, Seamans & Co., by J. C. Campbell; Rennselaer Mfg. Co., by C. L. Brown and F. S. Bates; Ross Valve Co., by Wm. Ross; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by F. L. Northrop, A. S. Otis, W. F. Hogan, and L. P. Anderson; R. D. Wood & Co., by W. F. Woodburn. — 22.

GUESTS.

Arthur E. Blackmer, Supt. Water Works, Plymouth, Mass.; James E. Blake, Attleboro, Mass.; D. Potter, Braintree, Mass.; J. F. Gleason, Quincy, Mass., and Frank Grady, Comr., Medford, Mass. — 5.

[Names counted twice. — 3.]

The following were elected members: Edgar A. Weimer, Mayor, Lebanon, Pa.; Dr. Howard Nelson Kingsford, Professor of Pathology and Bacteriology, Dartmouth College, and New Hampshire State Bacteriologist, Hanover, N. H.; Irving T. Farnham, City Engineer, Newton, Mass.; W. F. McFarland, Superintendent Water Department, Washington, D. C.; Ira Gould Hoagland, connected with the Underwriters Bureau of New England, Auburndale, Mass.

There was no special business to come before the meeting, and the President called at once upon Mr. A. O. Doane, Division Engineer, Metropolitan Water and Sewerage Board, Boston, to read his paper on "Water Pressure Regulators." The subject was discussed by Messrs. William Ross, Frank L. Northrup, and George A. Caldwell, representing the manufacturers, and by Messrs. Edwin C. Brooks, Freeman C. Coffin, Charles N. Taylor, and F. I. Winslow.

Mr. Frank H. Crandall, chairman of the Committee on Private Fire Services. submitted a report in behalf of the committee, which was accepted and adopted by the association. The subject was discussed by Messrs. John C. Chase, Edward V. French, J. C. Hammond, Jr., Charles W. Sherman, Charles K. Walker, Frank C. Kimball, Horace G. Holden, Charles N. Taylor, R. C. P. Coggeshall, George H. Snell, and Frank L. Fuller. Mr. French, in the course of his remarks, made an appropriate allusion to the death of Mr. Edward Atkinson.

The subject announced for topical discussion was "Electrolysis." The discussion was opened by Mr. Edwin C. Brooks, of Cambridge. He was followed by Messrs. William E. Foss, John A. Gould, T. C. Gleason, R. C. P. Coggeshall, A. N. French, Edward V. French, and George E. Winslow.

On motion of Mr. Brooks, adjourned.

ANNUAL MEETING.

HOTEL BRUNSWICK,
BOSTON, January 10, 1906.

The President, Mr. George Bowers, in the chair.

The following members and guests were present:

MEMBERS.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, H. K. Barrows, G. W. Batchelder, George Bowers, E. C. Brooks, G. A. P. Bucknam, James Burnie, E. J. Chadbourne, John C. Chase, W. F. Codd, F. C. Coffin, R. C. P. Coggeshali, M. F. Collins, W. R. Conard, J. H. Cook, G. K. Crandall, John Doyle, E. R. Dyer, G. E. Evans, F. L. Fuller, J. C. Gilbert, A. S. Glover, J. W. Griffin, R. A. Hale, J. O. Hall, J. C. Hammond, Jr., J. D. Hardy, H. G. Holden, E. W. Kent, Willard Kent, F. C. Kimball, G. A. King, Horace Kingman, C. F. Knowlton, J. W. Locke, M. O. Leighton, S. H. McKenzie, Hugh McLean, H. V. Macksey, D. E. Makepeace, A. E. Martin, W. E. Maybury, John Mayo, A. S. Merrill, F. E. Merrill, H. A. Miller, T. W. Norcross, E. B. Phelps, W. W. Robertson, S. P. Senior, C. W. Sherman, Sidney Smith, G. H. Snell, G. A. Stacy, J. T. Stevens, W. F. Sullivan, W. M. Stone, L. A. Taylor, R. J. Thomas, W. H. Thomas, W. H. Vaughn, R. S. Weston, W. J. Wetherbee, J. C. Whitney, F. B. Wilkins, G. E. Winslow, E. T. Wiswall. — 69.

HONORARY MEMBERS.

William T. Sedgwick. — 1.

ASSOCIATES.

Chapman Valve Mfg. Co., by Edw. F. Hughes; Charles A. Claflin & Co., by Charles A. Claflin; Henry A. Desper; M. J. Drummond & Co., by Walter J. Drummond; The Fairbanks Co., by F. A. Leavitt; Fred C. Gifford; Hersey Mfg. Co., by Albert S. Glover, J. A. Tilden, F. A. Smith; Lead Lined Iron Pipe Co., by T. E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; H. Mueller Mfg. Co., by George A. Caldwell; Neptune Meter Co., by H. H. Kinsey; National Meter Co., by C. H. Baldwin and J. G. Lufkin; Perrin, Seamans & Co., by C. E. Godfrey; The Platt Iron Works Co., by F. H. Hayes; Rensselaer Mfg. Co., by F. S. Bates and C. L. Brown; Ross Valve Co., by Wm. Ross; A. P. Smith Mfg. Co., by D. F. O'Brien and F. N. Whitcomb; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by F. L. Northrop, W. F. Hogan, Edw. P. King; R. D. Wood & Co., by W. F. Woodburn; Water Works Equipment Co., by W. H. Van Winkle. — 28.

GUESTS.

Patrick Gear, Asst. Supt., Holyoke, Mass.; F. P. Webster, Supt., Lakeport, N. H.; Eugene F. Garvey, Engr's Dept., Worcester, Mass.; A. R. McCollum, Supt., Whitman, Mass.; F. W. Holden, Norton, Mass.; J. F. Gleason, Supt., Quincy, Mass.; C. B. Breed, Boston, Mass.; Mr. Pratt, Portland, Conn.— 8.

[Names counted twice. — 3.]

The following named were elected to membership:

Active. — A. R. McCallum, Superintendent of Whitman Water Works, Whitman, Mass.; Eugene F. Garvey, Civil Engineer on Water Works Construction for the city of Worcester, Worcester, Mass.; Claude L. Howes, Engineer, Boston, Mass.

Associate. — The Anderson Coupling Company, Water Works Supplies, Portland, Conn.

President Bowers then delivered the following address:

President's Address.

Gentlemen of the New England Water Works Association, — Another year has passed away, and, as is our custom, we will review our year's work, or, as our M. I. T. friends across the street would say, take our annual examination.

Our first meeting of the year, January 11, was Ladies' Day, when we went on a personally conducted tour with our former president, Mr. Desmond FitzGerald, through the Philippines. By means of his fine lantern slides he showed us the present water works at Manila, and explained what it is intended to do there in the future. He also showed pictures of the people and their mode of living, closing a most interesting lecture with a series of beautiful views.

In February, we learned from Mr. Harvey D. Eaton what one man by persistent effort could accomplish in the way of securing municipal ownership of water supply, in the Kennebec water district. By combining several towns into a common water district, he has practically overthrown the old idea that town lines must always be recognized in constructing water works. This appears to be a movement in the right direction. Valuable papers were read by Mr. George C. Whipple and Dr. E. C. Levy on "The Kennebec Valley Typhoid Fever Epidemic of 1902 and 1903," showing conclusively that if people drink polluted water they must suffer the consequences. These papers were a very good preparation for what was to follow at the next meeting, which was held in March. At that time Prof. Erastus G. Smith explained the conditions existing along the Mississippi River, where that water is used as a means of supply, and the reckless manner in which the cities on its banks pollute the water. From our own experience in the East, we know the terrible effects that are sure to follow such inexcusable carelessness.

At the March meeting, also, a paper was read by Mr. William F. Sullivan on "Tests of Large Meters and Fire Service Devices," in which he showed that the large volume of water used in the fire service could be measured without lessening its effectiveness. The insurance members disagreed with Mr. Sullivan, and promised to announce later the results of their own experiments on this subject; they did so in September, when Mr. E. V. French reported what they had done and stated that they were convinced that, by a suitable device, the water could be measured without detriment to the fire protection. This problem has been before the association for several years, and its solution should be a matter of general congratulation.

The invitation from the water commissioners of Attleboro, through Mr. George H. Snell, superintendent, to visit that place for our June outing and inspect the reinforced concrete standpipe then in process of construction, was accepted. On the arrival at that place of our party of 153, we found automobiles waiting to carry us to the standpipe, which is some distance from the center of the town. The work here was examined with a great deal of interest, but I shall not attempt to describe it, as Mr. Snell has promised to give us a paper on that subject later on. After stopping a short time to admire the magnificent view, we were carried to the pumping station, where we found a thoroughly up-to-date plant, of which the citizens of Attleboro may well feel proud. Entering the automobiles once more, we were taken back to the town at a rate that led us to judge that the speed limit law was a thing unknown to Attleboro chauffeurs. After enjoying a fine dinner, provided by our hosts, we were shown through several of the silver manufactories for which this place is noted. Thus ended one of our most enjoyable summer outings.

September 11, we left Boston for our Annual Convention, which was held this year in New York City. From first to last this convention was a grand success. The meetings were well attended, the papers, which I will not enumerate separately, interesting and instructive, and the discussions which followed, general and exhaustive. With 575 guests to attend to, the office of the Entertainment Committee was no sinecure. An automobile ride, a visit to the Hippodrome, a trip to Coney Island, a ride through the subway, and a day at the Croton Dam were among the attractions provided us. The thanks of this association are certainly due the Committee on Arrangements and their sub-committees, whose efficient work made this in every respect the record-breaking convention of our society.

At the November meeting, introductory papers on the " Present Relative Responsibility of Public Water Supplies and Other Factors in the Causation of Typhoid Fever " were read by Dr. W. T. Sedgwick and Prof. C.-E. A. Winslow, explaining the various causes of typhoid epidemics. Then followed papers by Mr. E. E. Lochridge and Dr. George B. Magrath on the Springfield, Mass., typhoid epidemic, which was originally supposed to be caused by the water, but was readily traced by them to unsanitary conditions, showing negligence on the part of the board of health instead of the water board.

In December, Mr. A, O. Doane read a paper on " Water Pressure Regulators," which was fully discussed. The report of the Committee on Private Fire Services was read; this was followed by the discussion which this subject always brings out. Mr. Edwin C. Brooks exhibited a piece of cast-iron water pipe, several feet long, showing in a marked degree the effect of electrolysis, and explained the difference in the appearance of the pipe when taken from the ground and after several months' exposure to the atmosphere, and a general discussion on this subject followed.

That these meetings have been appreciated is shown by the large attendance throughout the year, and the increase of our membership from 604, January 1, 1905, to 645 at the present time.

We have sustained a great loss during the year in the death of five active members, Edward Atkinson, Henry A. Cook, Frank L. Fales, August Fels, and A. G. Pease, and one associate member, Edward Robinson.

Our headquarters at Tremont Temple have been enlarged by the addition of two rooms, so that we now have plenty of room for social intercourse before our meetings, and a separate room where the Executive Committee can hold its sessions undisturbed. We have just obtained a lease for a term of three years from the Boston Society of Civil Engineers at the same price paid before the additional rooms were secured. We feel sure that the members of this association will appreciate these convenient rooms and also the excellent library, and we hope they will use them freely.

This association has always been well to the front in the discussion of matters within its sphere, its papers being the first brought out on many important subjects. It has been a director in many advanced ideas for the care and protection of water supplies, so that at the present time most of the water supplies in this vicinity are of good quality. Having secured good water, we should now exert ourselves to put a stop to the enormous waste of water which is going on around us. I was very glad to see that Mayor John F. Fitzgerald, in his inaugural address, recommended the use of water meters in Boston to remedy this evil, and I think his efforts in this direction should receive the support of our association. Fears are entertained that an additional water supply for Boston will be needed before long, and that some towns with their water supply will be seized, with the result that a new lake will make its appearance on the map. Such action should not be allowed while water is being wasted so needlessly, and should be guarded against by all the property owners of the state.

In conclusion, I should like to say a word about the JOURNAL, which, under the management of its energetic editor, is steadily increasing in value. The December number just issued, which contains a record of the copper sulphate discussion, will rank with any scientific magazine of the day.

All information in regard to membership and finance will be contained in the reports of the Secretary and Treasurer, which follow immediately.

I wish to thank you for the cordial manner in which you have supported me during the year, and to congratulate the association on the loyalty of its members.

REPORT OF SECRETARY.

The Secretary submitted the following report:

MEMBERSHIP.

The total membership of the association, January 1, 1905, was	604
The present membership is	645
A net increase during the year of	41

MEMBERS.

January 1, 1905.	Total members		538	
	Withdrawals:			
	Resigned	8		
	Died	5		
	Dropped	50	63	
			475	
	Initiations:			
	January	4		
	February	6		
	March	5		
	June	12		
	September	57		
	November	18		
	December	3	105	
	Reinstated		4	584

HONORARY MEMBERS.

January 1, 1905.	Honorary members	8	
January 1, 1906.	Honorary members		8

ASSOCIATES.

January 1, 1905.	Total associates		58	
	Withdrawals:			
	Resigned	2		
	Died	1		
	Dropped	5	8	
			50	
	Initiations:			
	February	1		
	September	2	3	53
January 1, 1906.	Total membership			645

SUMMARY OF RECEIPTS AND DISBURSEMENTS OF THE NEW ENGLAND WATER WORKS ASSOCIATION FOR THE YEAR 1905.

RECEIPTS.

Dues	$2 685.00
Advertisements	1 886.25
Initiations	410.00
Sundries	127.42
Subscriptions	126.50
Journals	103.05
	$5 338.22

DISBURSEMENTS.

Journal *	$2 072.04
Stationery	448.98
Assistant Secretary	420.00
Rent	400.00
Reprints and advance copies of papers	303.31
Sundry	302.96
Advertising Agent	300.50
Editor	300.00
Stenographer	240.75
Secretary	200.00
Membership list	127.83
Music	120.00
Badges	65.00
Furniture	34.00
Stereopticon	20.00
Library	15.00
Total	$5 370.37

Expenditures in excess of receipts	$32.15

At the present time there is due the association:

For advertisements	$510.00
For reprints	6.50
For standard specifications	.40
For Journals	5.00
	$521.90

I know of no outstanding bills against the association.

Respectfully submitted,

WILLARD KENT, *Secretary.*

On motion of Mr. M. F. Collins the report of the Secretary was accepted and ordered to be placed on file.

REPORT OF TREASURER.

The Treasurer submitted the following as his annual report:

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* Including printing and illustrating only. — ED.

LEWIS M. BANCROFT, TREASURER,
In account with the New England Water Works Association.

RECEIPTS.

Date		Item		
1905.				
Jan.	5	Balance on hand		$2 869.15
Aug.	1	Dividend, Peoples' Savings Bank		54.67
Dec.	3	Dividend, Mechanics Savings Bank		38.27
Feb.	23	Rec'd of Willard Kent, Sec'y,	$1 620.00	
April	17	" " " "	345.01	
June	23	" " " "	516.05	
July	27	" " " "	272.75	
Oct.	9	" " " "	790.66	
Nov.	18	" " " "	821.65	
1906.				
Jan.	3	" " " "	972.10	5 338.22
				$8 300.31

EXPENDITURES.

Item		
Bills paid, as per itemized statement		$5 411.58
BALANCE ON HAND.		
Deposit Peoples' Savings Bank, Worcester	$1 506.05	
Deposit Mechanics Savings Bank, Reading	1 122.35	
Deposit First National Bank, Reading	260.33	
Total balance		2 888.73
		$8 300.31

LEWIS M. BANCROFT, *Treasurer.*

READING, MASS., January 5, 1906.

DETAILED STATEMENT OF BILLS PAID.

1905.			
January	6	Miss J. M. Ham, ass't sec'y, December, 1904, salary,	$35.00
		Miss J. M. Ham, ass't sec'y, express, postage, etc.,	6.21
	24	William E. Whittaker, tracings	6.00
		Annie H. Virtue, music for January meeting	60.00
		Thomas P. Taylor, stereopticon	10.00
		W. N. Hughes, book, dues 1905	6.00
		R. C. P. Coggeshall, expense auditing accounts	4.25
		William W. Robinson, expense auditing accounts	4.50
	27	W. N. Hughes, envelopes and cards	12.75
		Hub Engraving Company, plates	5.80
February	4	Miss J. M. Ham, ass't sec'y, salary for January, 1905	35.00
		Miss J. M. Ham, ass't sec'y, cash paid for express, etc.	13.96
	21	L. M. Bancroft & Son, treasurer's bond	15.00
	28	Miss J. M. Ham, ass't sec'y, salary for February	35.00
		Miss J. M. Ham, ass't sec'y, Committee on Meter Rates	6.50
		W. N. Hughes, envelopes and printing	22.25
		Hub Engraving Company, plates	13.28
March	2	Daggett's Orchestra, music, February meeting	15.00
	11	D. Gillies' Sons, stationery and printing	64.81
		Boston Society of Civil Engineers, rent to February 28	100.00
	31	Thomas P. Taylor, stereopticon	10.00
		Daggett's Orchestra, music, March meeting	15.00
		Charles W. Sherman, salary and expenses to April 1,	91.00
		Hub Engraving Company, plates	19.48
April	10	Hub Engraving Company, plates	2.25
		W. N. Hughes, binding	5.00
		Bacon & Burpee, reporting January, February, and March meetings	40.00
		Miss J. M. Ham, ass't sec'y, salary for March	35.00
May	3	Samuel Usher, printing March JOURNAL, reprints, and lists of members	599.73
		R. J. Thomas, advertising agent, commissions to April 1	74.50
		Miss J. M. Ham, ass't sec'y, salary for April	35.00
		Willard Kent, secretary, salary to April 1	50.00
		Willard Kent, secretary, sundry expenses	53.90
June	1	D. Gillies' Sons, applications	7.75
		Miss J. M. Ham, ass't sec'y, salary for May	35.00
		Amount carried forward	$1 544.92

		Amount brought forward	$1 544.92
		Hub Engraving Company, plates	3.60
June	10	W. N. Hughes, envelopes and printing	55.00
		Charles W. Sherman, editor, salary and expenses to July 1	83.25
		Boston Society of Civil Engineers, rent to May 31	100.00
	17	W. N. Hughes, envelopes and printing	45.58
	26	Miss J. M. Ham, ass't sec'y, salary for June	35.00
		R. J. Thomas, advertising agent, commissions to July 1	75.75
July	5	D. Gillies' Sons, printing	17.00
		Willard Kent, secretary, salary to July 1	50.00
		Willard Kent, secretary, sundry expenses	15.00
	18	Samuel Usher, June JOURNAL and reprints	305.45
	26	Miss J. M. Ham, ass't sec'y, salary for July	35.00
August	14	W. N. Hughes, printing	3.50
		S. E. Tinkham, cash paid for cleaning books	4.00
	25	Hub Engraving Company, plates	14.80
	30	Miss J. M. Ham, ass't sec'y, salary for August	35.00
		Miss J. M. Ham, ass't sec'y, sundry expense items,	37.84
September	6	W. N. Hughes, printing	5.00
	18	American Society of Civil Engineers, binding	6.00
		Charles W. Sherman, editor, salary to October 1,	75.00
		Charles W. Sherman, editor, sundry expenses	7.65
		Samuel Usher, reprints	58.81
		Hub Engraving Company, plates	95.19
	30	Whitehead & Hoag Company, badges	65.00
		The Globe-Wernicke Company, bookcases	34.00
		William E .Whittaker, tracings	3.00
October	3	Miss J. M. Ham, ass't sec'y, salary for September	35.00
		Miss J. M. Ham, ass't sec'y, sundry expenses	74.00
		Willard Kent, secretary, salary to October 1	50.00
		Willard Kent, secretary, sundry expenses	10.00
		Bacon & Burpee, reporting New York Convention	141.50
	10	D. Gillies' Sons, printing	52.85
		Boston Society of Civil Engineers, rent to August 31,	100.00
	17	Hub Engraving Company, plates	37.01
		W. N. Hughes, printing	23.00
	31	W. N. Hughes, printing	5.00
		Miss J. M. Ham, ass't sec'y, salary for October	35.00
November	3	Hub Engraving Company, plates	20.37
	7	W. N. Hughes, printing	12.00
	16	Hub Engraving Company, plates	4.60
		Amount carried forward	$3 410.67

	Amount brought forward	$3 410.67
	D. Gillies' Sons, printing	16.50
November 22	R. J. Thomas, advertising agent, commissions to November 1	76.50
December 5	Samuel Usher, September JOURNAL and reprints .	545.30
	Miss J. M. Ham, ass't sec'y, salary for November .	35.00
	W. N. Hughes, printing	2.00
15	Hub Engraving Company, plates	10.02
	Miss J. M. Ham, ass't sec'y, salary for December .	35.00
	Miss J. M. Ham, ass't sec'y, Committee on Meter Rates	3.50
	Miss J. M. Ham, ass't sec'y, sundry expenses . .	21.38
	D. Gillies' Sons, printing	26.95
	Charles W. Sherman, editor, salary to December 31,	75.00
	Charles W. Sherman, editor, sundry expenses . .	10.65
18	W. N. Hughes, printing	7.75
	Willard Kent, secretary, salary to December 31 .	50.00
	Willard Kent, secretary, sundry expenses	74.40
23	Boston Society of Civil Engineers, rent to November 30	100.00
26	Samuel Usher, reprints	69.50
	Bacon & Burpee, reporting November and December meetings	59.25
	Frank E. Merrill, expenses account September convention	13.47
30	W. N. Hughes, dues book	6.00
	R J. Thomas, advertising agent, commissions to December 3	73.75
	Samuel Usher, December JOURNAL	688.99
		$5 411.58

On motion of Mr. Tighe the report of the Treasurer was accepted and ordered placed on file.

REPORT OF EDITOR.

The Editor submitted the following report:

JANUARY 10, 1906.

To the New England Water Works Association, — The following is my report as Editor of the JOURNAL for the year 1905.

The accompanying tables show in detail the amount of material in the JOURNAL, the receipts and expenditures, and a comparison with the five preceding volumes.

TABLE No. 1.

STATEMENT OF MATERIAL IN VOLUME XIX, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1905.

Number.	DATE OF ISSUE.	NUMBER OF PAGES OF								Cuts.
		Papers.	Proceedings.	Total Text.	Index, etc.	Advertisements.	Covers and Contents.	Inset Plates.	Total.	
1	March	113	33	146	—	30	4	16	196	16
2	June	85	9	94	—	31	4	1	130	7
3	September	120	24	144	—	32	4	20	200	4
4	December	198	5	203	8	31	4	12	258	3
	Total	516	71	587	8	124	16	49	784	30

TABLE No. 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XIX, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1905.

RECEIPTS.		EXPENDITURES.	
From advertisements . . .	$1 886.25	For printing JOURNAL . .	$1 836.64
From sale of JOURNALS . .	103.05	For preparing illustrations	235.40
From sale of reprints . . .	77.90	For editor's salary	300.00
From subscriptions . . .	126.50	For editor's incidentals . .	50.05
	$2 193.70	For advertising agent's commissions	300.50
		For reporting	240.75
Net cost of JOURNAL . . .	$1 072.95	For reprints and advance copies	303.31
	$3 266.65	Gross cost of JOURNAL . .	$3 266.65

TABLE No. 3.

COMPARISON BETWEEN VOLUMES XIV, XV, XVI, XVII, XVIII, AND XIX, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

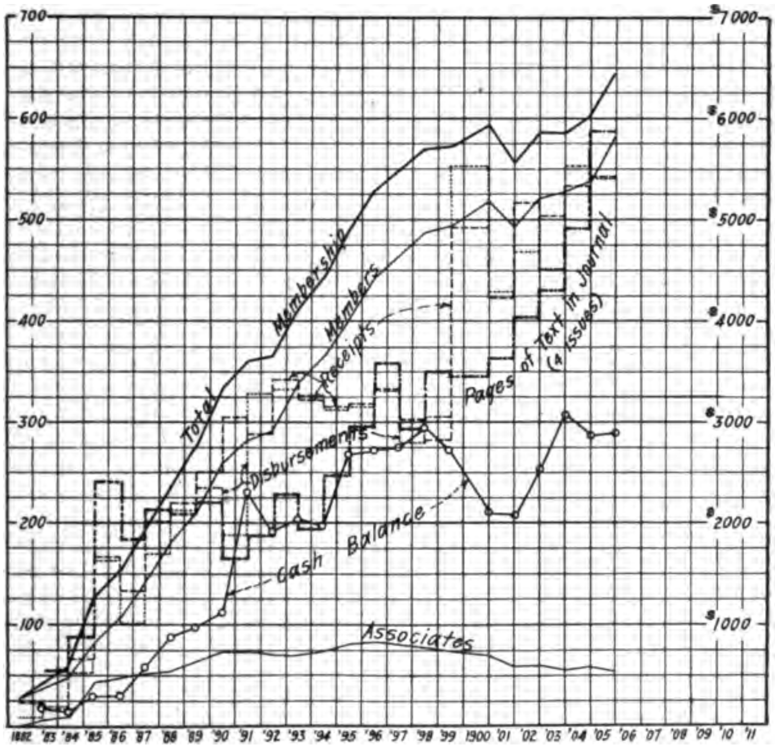
	VOL. XIV. 1899–1900.	4 NUMBERS OF VOL. XV. 1900–1901.	VOL. XVI. 1902.	VOL. XVII. 1903.	VOL. XVIII. 1904.	VOL. XIX. 1905.
Edition (copies)	1 100	1 200	1 200	1 200	900	900
Average membership	583	586	571	587	596	625
Pages of text	345	363	403	430	491	587
Pages of text per 1 000 members	600	618	707	733	824	939
Total pages, all kinds	485	536	584	619	794 *	784
Total pages per 1 000 members	832	913	1 020	1 051	1 332	1 254
GROSS COST:						
Total	$1 954.15	$2 194.26	$2 439.99	$2 706.05	$2 928.77	$3 266.65
Per page	4.03	4.10	4.18	4.38	3.69	4.17
Per member	3.35	3.75	4.27	4.61	4.91	5.23
Per member per 1 000 pages	6.91	6.99	7.32	7.46	6.18	6.67
Per member per 1 000 pp. text	9.71	10.31	10.60	10.72	10.00	8.91
NET COST:						
Total	$347.55	$332.90	$622.89	$770.62	$648.11	$1 072.95
Per page	.72	.62	1.07	1.25	.82	1.37
Per member	.60	.57	1.09	1.31	1.09	1.72
Per member per 1 000 pages	1.23	1.06	1.87	2.12	1.30	2.20
Per member per 1 000 pp. text	1.73	1.57	2.71	3.05	2.22	2.93

* Including General Index.

I submit also a diagram showing the principal statistics of the Association from its formation to the present time.

NEW ENGLAND WATER WORKS ASSOCIATION

PRINCIPAL STATISTICS



The December, 1905, issue contained 28.08 pages of paid advertisements, which, if maintained throughout a year, would mean an annual income from this source of $1 985.00. A year ago the figures were 27.92 pages and $1 935.00, showing a slight increase during the year.

The unusual size of the present volume of the JOURNAL is worthy of note. This is largely due to the volume of the papers presented at the New York Convention, and is a testimonial principally to the activity of the local committee on program, of which Mr. George W. Fuller was chairman. As regards quality, the papers speak for themselves. There certainly has been no reduction in the average quality of the papers published during the year.

The total cost of illustrations in the JOURNAL for the year has been $428.60, or 13.1 per cent. of the gross cost of the JOURNAL. This includes, in some cases, preparation of drawings, and in all cases making cuts and printing the illustrations. For the preceding volume the illustrations cost $300.83, which was 10.3 per cent. of the gross cost of the volume. The increase during the present year has been largely due to the cost of making and printing cuts to illustrate one or two papers, which papers, however, were of special interest and value and with which the illustrations were indispensable.

The usual fifty reprints of papers have been furnished to authors without charge; advance copies of a few of the papers presented have also been printed, which has made the item for reprints and advance copies considerably greater than usual. It is to be hoped that it may be possible in the near future to print all, or at least the greater part, of the papers to be presented before the association in advance, in order to allow more time for discussion and to make it possible to prepare discussions in advance. Up to the present, however, it has not been possible to secure many of the papers before the time of presentation. The net cost to the association of the reprints and advance copies has been $9.80 for each of the twenty-three papers published during the year.

The present circulation of the JOURNAL is:

Members (all grades)	645
Subscribers	44
Exchanges	16
	705

During the year pipe specifications have been sold to the amount of $28.70. A year ago we had a net gain of $28 from this source, so that at the present time we have received $56.70 more than the expense of printing these specifications. The association still has on hand a fair supply of the specifications.

I know of no outstanding bills against the association on account of the JOURNAL.

Respectfully submitted,

CHARLES W. SHERMAN, *Editor*.

On motion of Mr. Chase the report was accepted and ordered placed on file.

REPORT OF THE FINANCE COMMITTEE.

Mr. W. W. Robertson, chairman, submitted the following as the report of Finance Committee.

BOSTON, MASS., January 6, 1906.

To the Members of the New England Water Works Association, — We, the undersigned members of the Finance Committee of this association for the past year, met this day at the headquarters of this association at Tremont Temple in this city, and proceeded as follows:

We first examined the Secretary's cash book, verified the additions, and found the total receipts as stated therein to be correct and to the amount of $5 338.22, which amount the Secretary has transmitted to the Treasurer, and holds the receipt of the latter therefor. In the Secretary's report the amount uncollected from advertisements is seemingly large. It, however, is due to the fact that bills for same could not be issued until the December issue of the JOURNAL had been delivered. Sufficient time has not since elapsed to make the collection of this account.

An examination of the Treasurer's account shows that it agrees with that of the Secretary in the amount received, viz., $5 338.22. We have checked every item in his entries of disbursements, amounting to $5 411.58, and find each item properly approved and secured by vouchers. We have checked the Treasurer's statement of balance on hand January 6, 1906, $2 888.73, by examining his bank account, and find the same to be correct.

We, therefore, as the result of this examination vouch for the accuracy of statements contained in the reports of the Secretary and Treasurer, which are submitted to you this day.

Your committee feels that the association is to be congratulated in having its financial affairs administered by such competent officials as are now in charge of same. The books show a large amount of detail, which is rapidly increasing in bulk each year. By far the larger portion of this increase in work falls upon our present efficient Assistant Secretary, Miss J. M. Ham, whose books we found in an exceedingly creditable and neat condition. For some time Miss Ham has been receiving a salary of $35 per month. We think it only just that we should recognize the fact of her largely increased duties, due to the growth of the association. We therefore earnestly recommend that from this date onward Miss Ham's salary be increased to $45 per month.

Respectfully submitted,

W. W. ROBERTSON,
R. C. P. COGGESHALL,
HARRY L. THOMAS,
Finance Committee.

On motion of Mr. R. J. Thomas the report of the committee was accepted and that portion of it referring to an increase of salary of the Assistant Secretary was referred to the Executive Committee.

Election of Officers.

(REPORT OF TELLERS OF ELECTION.)

Boston, Mass., January 10, 1906.

Mr. President, — The tellers appointed to canvass the ballots for the election of officers of the New England Water Works Association, for the year 1906, beg leave to report as follows:

Whole number of votes cast, 214.

For President.

*William T. Sedgwick, Boston, Mass.	214

For Vice-Presidents.

*J. Waldo Smith, New York, N. Y.	211
*Cyrus M. Lunt, Lewiston, Me.	209
*Frank A. Andrews, Nashua, N. H.	212
*John C. Chase, Derry, N. H.	210
*Frederick W. Gow, Medford, Mass.	212
*Joseph M. Birmingham, Hartford, Conn.	210
George H. Snell, Attleboro, Mass.	1
George A. King, Taunton, Mass.	1

For Secretary.

*Willard Kent, Narragansett Pier, R. I.	212
†J. M. Ham	1

For Treasurer.

*Lewis M. Bancroft, Reading, Mass.	211

For Editor.

*Charles W. Sherman, Boston, Mass.	212

For Advertising Agent.

*Robert J. Thomas, Lowell, Mass.	212

For Additional Members of Executive Committee.

*Frank E. Merrill, Somerville, Mass.	212
*George A. Stacy, Marlboro, Mass.	213
*James L. Tighe, Holyoke, Mass.	212

For Finance Committee, Three.

*Harry L. Thomas, Hingham, Mass.	213
*William E. Mayberry, Braintree, Mass.	213
*Arthur D. Marble, Lawrence, Mass.	214

Respectfully submitted,

WILLIAM F. SULLIVAN,
GEORGE A. KING,
Tellers.

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* Elected. † Ineligible.

The President announced the election of the various officers as shown by the return of the tellers and then presented to the Association as its next president, " a man you all know and whom you all love, a man who has done as much for the association as any other member, Professor Sedgwick." [Applause.] Professor Sedgwick responded as follows:

Mr. President and Fellow Members, — When, a little over a year ago, you were kind enough to elect me an honorary member of this association, it seemed to me that you had done all and more than you ought to have done for me. I think I have never had a chance to express my thanks, as I now do, for that distinguished honor at your hands. But when in addition you have chosen me as your President for the ensuing year, you have indeed placed me under still greater obligation.

I should be a very conceited person if I supposed that in doing this you were conferring the distinction upon me alone, for I know it is rather upon the institution with which I am connected, and have been for many years, and upon my associates, former students, and friends who have been working along the same lines that I as a scientific man have been pursuing. And in that spirit, and as a token of your confidence, I have great pleasure in accepting, as I now do, the high honor which, in another form, you have for the second time conferred upon me.

I believe in this association. I have been with you here for a good many years, and I believe in the work that you are doing. A man who is a water-works superintendent or a water-works expert cannot be altogether a fool, and when his friends and his peers choose him for a place like this, it means a great deal. We have all worked together for a common end, the improvement of one of the great public services of the day; and the growth of the association, together with its reputation, which has grown with its membership, is a sufficient guarantee of the place which it now holds in American professional life. This might well be called an association of water-works engineers, but it has the more modest title of Water Works Association; and while limited in name to New England, it reaches in fact, as you know, all over the country.

It is one of the delightful things of our day that bodies of trained men are getting together and correcting that over-specialization which is so characteristic of our times, by organization, bringing together men of kindred tastes and kindred pursuits. Our constitution states that this association is formed for "the advancement of knowledge relating to water works and water supply, and the encouragement of social intercourse among water-works men." We could not possibly have a better charter — improvement of our knowledge and improvement of our acquaintance, one with another. Let us see to it during the coming year, as we have seen to it during the years that have gone, that while adding to our knowledge we are also adding to our good fellowship. Let us look out particularly for the man who is off in some little place, facing problems which are quite as difficult for him as those which confront men in charge of bigger works, and let us also see to it that the good fellowship element is looked after in his case, which is often harder to manage than the purely professional problem. In view of all the splendid work which has been done by the association in the past, in view of the able administrations under which the association has grown large and strong, let us see if in this year which is to come we may not do even better work than ever before, — better for our science, better for good fellowship.

At our meeting next month, as you know, we are to have the ladies with us, and the committee having charge of the arrangements for Ladies' Day proposes, if its plans can be carried out, to furnish an unusually attractive program. I am happy to say that Mrs. Sedgwick will be here with me, and for half an hour or so before we sit down to dinner we will have a little social gathering and I hope you will all bring your wives or sweethearts or daughters, for after dinner we expect to have something which will be of interest to all. I trust there will be a large attendance and that it will be a banner day among all our ladies' days.

Now I am not going to talk any longer at present. You will have to bear with me for a whole year, and therefore I will cut my remarks short on this occasion, although I will not promise always to do as well in this respect. [Applause.]

The paper of the afternoon was on "Water-Works Construction of the United States Reclamation Service," by Mr. M. O.

Leighton, hydrographer in charge, Division of Hydro-Economics. It was illustrated by stereopticon views. At the close of his address Mr. Leighton answered questions asked by Messrs. Charles W. Sherman, Frank L. Fuller, John C. Whitney, and Sidney Smith.

Just before the meeting adjourned, Mr. R. C. P. Coggeshall said:

"There is one thing I want to bring up at this time. I was very much impressed by our President's modest résumé of the past year's work. I know something of what the administration has had in hand in carrying out that work, and I know how much the success of it has been due to our President. I think it is a good plan to recognize such service as he has given us in some formal way, and I, therefore, am going to make this motion, which I shall ask the Secretary to put, that the thanks of the association be given to George Bowers, the retiring president, for the excellent service which he has rendered us during the past year." [Loud applause.]

The motion was put by the Secretary and adopted by a rising vote.

President Bowers. I thank you very much, gentlemen, for this expression of your appreciation and good-will.

February Meeting (Ladies' Day).

Hotel Brunswick,
Boston, February 14, 1906.

Prof. Wm. T. Sedgwick, President, in the chair.

The following members and guests were in attendance:

Members.

S. A. Agnew, F. E. Appleton, C. H. Baldwin, G. W. Batchelder, J. E. Beals, George Bowers, Fred. Brooks, James Burnie, F. H. Carter, J. C. Chase, R. C. P. Coggeshall, M. F. Collins, J. H. Cook, M. J. Doyle, A. O. Doane, I. T. Farnham, J. H. Flynn, J. C. Gilbert, A. S. Glover, C. A. Hague, L. M. Hastings, G. W. Hawkes, H. G. Holden, J. L. Howard, H. R. Johnson, E. W. Kent, Willard Kent, G. A. King, Hugh McLean, H. V. Macksey, A. E. Martin, W. E. Maybury, John Mayo, F. E. Merrill, H. A. Miller, William Naylor, C. E. Peirce, T. A. Peirce, E. B. Phelps, Dwight Porter, W. H. Richards, C. W. Sherman, G. A. Stacy, C. N. Taylor, R. J. Thomas, D. N. Tower, W. H. Vaughn, R. S. Weston, J. C. Whitney, G. E. Winslow, F. E. Winsor, and E. T. Wiswall. — 52.

Honorary Member.

W. T. Sedgwick. — 1.

Associates.

Harold L. Bond & Co., by Harold L. Bond; Chapman Valve Manufacturing Company, by Edw. F. Hughes; Coffin Valve Company, by H. L. Weston; Henry A. Desper; Fred C. Gifford; Hersey Manufacturing Company, by Albert S. Glover, J. A. Tilden, W. A. Hersey, and Wm. C. Sherwood; International Steam Pump Company, by Samuel Harrison; Lead Lined Iron Pipe Company, by T. E. Dwyer; Ludlow Valve Manufacturing Company, by H. F. Gould; H. Mueller Manufacturing Company, by George A. Caldwell; National Meter Company, by C. H. Baldwin and J. G. Lufkin; Neptune Meter Company, by H. H. Kinsey; Perrin, Seamans & Co., by J. C. Campbell; Platt Iron Works Company, by F. H. Hayes; Rensselaer Manufacturing Company, by F. S. Bates; Ross Valve Company, by Wm. Ross; A. P. Smith Manufacturing Company, by F. N. Whitcomb; Thomson Meter Company, by S. D. Higley; Union Water Meter Company, by F. L. Northrop and W. F. Hogan; United States Cast Iron Pipe and Foundry Company, by Frank W. Nevins; Waldo Brothers, by E. W. Clark; R. D. Wood & Co., by W. F. Woodburn; Water Works Equipment Company, by W. H. Van Winkle. — 28.

GUESTS.

Mrs. Charles N. Taylor, Mrs. W. H. Vaughn, Wellesley Hills, Mass.; Miss Helen Willson, Mrs. Arthur I. Nash, Mrs. E. D. Phelps, Mrs. J. L. Howard, Mrs. Frank E. Winsor, Mrs. H. A. Miller, Mrs. A. O. Doane, Mrs. J. H. Flynn, Mrs. Frank C. Kimball, Miss Florence C. Kimball, Mrs. Samuel Harrison, Mr. Scribner, Mr. George E. Russell, Mr. Shepard, Boston, Mass.; Miss Alice S. Corner, P. J. B. Sullivan, R. Connor, Holyoke, Mass.; Mr. and Mrs. J. F. Gleason, Quincy, Mass.; Mrs. I. T. Farnham, West Newton, Mass.; Mrs. C. E. Peirce, East Providence, R. I.; Mrs. George E. Winslow, Waltham, Mass.; Mrs. George A. Stacy, Marlboro, Mass.; Mrs. A. B. Arey, Miss Edith Arey, South Boston, Mass.; Mrs. F. H. Hayes, Mrs. E. C. Brooks, Cambridge, Mass.; Mrs. Willard Kent, Narragansett Pier, R. I.; Mrs. George Bowers, Mrs. F. E. Appleton, R. R. Thomas, Mrs. C. S. Proctor, Lowell, Mass.; Mrs. Wm. T. Sedgwick, Wm. E. Mott, Brookline, Mass.; J. F. James, Lawrence, Mass.; Mr. and Mrs. H. W. Sears, Mr. and Mrs. Walter L. Beals, Middleboro, Mass.; Mrs. John C. Chase, Derry, N. H.; Mrs. H. G. Holden, Nashua, N. H.; Mrs. John H. Cook, Paterson, N. J.; Mrs. Charles W. Sherman, Belmont, Mass.; Miss Lillian Leavitt, Somerville, Mass.; Miss Helen R. Coggeshall, New Bedford, Mass.; Mrs. W. H. Richards, Miss Helen M. Richards, H. S. Richards, New London, Conn.; Mrs. Thomas A. Peirce, East Greenwich, R. I. — 51.

The following applicants, who were recommended by the Executive Committee, were elected to membership:

C. H. Turner, Treas. St. Johnsbury Aq. Co., St. Johnsbury, Vt.; W. Donaldson, Knoxville Water Co., Knoxville, Ky.; Frank E. Pressey, Hydgr., U. S. G. S., Bangor, Me.; A. B. Hill, Cons. Eng., New Haven, Conn.; Herbert P. Linnell, Res. Eng., Water Works, Colon, Cristobal, Canal Zone; H. J. Glendenning, C. E., Portland, Me.; C. Robert Adams, U. S. G. S., Boston; Edward R. Mack, Water Department, Wilmington, Del.; Horace H. Chase, C. E., Brockton, Mass.; Peter A. Monteverde, Superintendent, Trafford City, Trafford County, Pa.; Lewis E. Smith, C. E., Pasadena, Cal.; Edmund M. Blake, C. E., Boston.

President Sedgwick welcomed the ladies and called attention to the happy coincidence of our Ladies' Day falling upon St. Valentine's Day, after which he introduced Arthur I. Nash, Esq., of Boston, who gave a very interesting address, illustrated by stereopticon, on the beaver, under the title, "Primitive Water Works and Water Workers of New England."

Adjourned.

EXECUTIVE COMMITTEE.

DECEMBER 13, 1905.

Present: President George Bowers, and George A. Stacy, Robert J. Thomas, L. M. Bancroft, Charles W. Sherman, and Willard Kent.

The Secretary read applications for membership from the following persons:

Irving T. Farnham, Howard N. Kingsford, Ira G. Hoagland, Edgar A. Weimer, and W. A. McFarland; and it was voted to recommend the applicants for election.

A letter was read from Mr. Luther C. Wright, superintendent, Water Works, Northampton, Mass., a former member of the association in good standing, signifying his desire to again become a member. By unanimous vote of the Executive Committee, Mr. Wright was reinstated to membership in the association.

On motion of Mr. Sherman it was voted: That surplus numbers of the JOURNAL of the Association, in excess of five copies of each issue, be disposed of at the rate of one dollar each.

Voted: That the President be and hereby is authorized to appoint a special committee to make arrangements for Ladies' Day on the date of the February meeting.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

BOSTON, January 10, 1906.

Present: President George Bowers, and Frank E. Merrill, James L. Tighe, Charles W. Sherman, Frederick W. Gow, L. M. Bancroft, Robert J. Thomas, and Willard Kent.

Applications were received from A. R. McCallum, Whitman, Mass.; Eugene F. Garvey, Worcester, Mass.. and Claude L. Howes, M. E., Boston, Mass., for active membership, and from the Anderson Coupling Company, of Portland, Conn., for associate membership, and they were by vote unanimously recommended therefor.

The salary of the Assistant Secretary, on recommendation of the Finance Committee, was by vote increased to forty-five dollars ($45) per month.

Adjourned.

Attest: Willard Kent, *Secretary.*

February 14, 1906.

Present: John C. Chase, chairman; Frank E. Merrill, George A. Stacy, James L. Tighe, Willard Kent, Charles W. Sherman, and Robert J. Thomas.

Applications were received from C. H. Turner, St. Johnsbury, Vt.; W. Donaldson, Knoxville, Tenn.; Frank E. Pressey, Bangor, Me.; Albert B. Hill, New Haven, Conn.; Edward R. Mack, Wilmington, Del.; Horace H. Chase, Brockton, Mass.; Peter A. Monteverde, Trafford City, Pa.; Lewis E. Smith, Pasadena, Cal.; Herbert P. Linnell, Cristobal, Canal Zone; H. J. Glendenning, Portland, Me.; C. Robert Adams, Boston, Mass.; and Edmund M. Blake, Boston, Mass.; and they were by vote recommended for membership in the association.

Adjourned.

Attest: Willard Kent, *Secretary.*

OBITUARY.

Edward Atkinson, president of the Boston Manufacturers' Mutual Fire Insurance Company, and well known as an economist and statistician, as well as perhaps the leading " anti-imperialist " of the country, died suddenly on December 11, 1905, as the result of an attack of acute indigestion, with which he was seized while driving from his home to his office that morning.

Mr. Atkinson was born in Brookline, Mass., on February 10, 1827, and was educated in private schools. His business training began in 1842 in a commission house; in 1848 he became identified with various manufacturing corporations, which he served as clerk or treasurer until 1877. He had been president of the Boston Manufacturers' Mutual Fire Insurance Company for nearly forty years. In this position he was the prime mover in establishing the inspection department of the Associated Factory Mutual Insurance Companies, which has done so much to advance, not only methods of construction, but our knowledge of principles and our practice in hydraulic engineering.

For many years he had been a vigorous and fearless writer on a wide range of subjects. He was a member of many societies, and had received many honors, among them the honorary degrees of LL.D. and Ph.D. He was one of the founders and for several years a member of the corporation of the Massachusetts Institute of Technology. He contributed two papers to this association on bog fuel, and frequently took part in the discussions.

Mr. Atkinson became a member of the New England Water Works Association on November 9, 1904.

BOOK NOTICES.

PRACTICAL CEMENT TESTING. By W. Purves Taylor, M.S., C.E., Engineer in charge, Philadelphia Municipal Testing Laboratory. New York: The Myron C. Clark Publishing Company, 13–21 Park Row. 1906. Pp. 315. 6 x 9 inches. Price, $3.00 net.

This book is, perhaps, the most complete work ever published on the subject of cement testing, and although from the number of pages it might be thought voluminous, it is concise and admirably arranged. It has been prepared with a view to its use by the novice in testing, and the matter is so presented as to be readily understood by him; at the same time it will doubtless prove of much value as a book of ready reference for the expert.

The first three chapters are of an introductory character, and deal briefly with the classification, constitution, and manufacture of cements. The body of the book, comprising Chapters 4 to 12, deals very fully with the usual or routine tests of cement and discusses the methods of making them and the interpretation of results. The remainder of the book is devoted to special tests, chemical analyses, methods of operating a laboratory, and numerous specifications. Mr. Taylor's wide experience in charge of the Philadelphia municipal laboratory is abundant proof of his qualifications for preparing such a book.

There are numerous illustrations, diagrams, and tables scattered through the book, which is concluded by a good index.

HANDBOOK OF COST DATA FOR CONTRACTORS AND ENGINEERS. A Reference Book giving Methods of Construction and Actual Costs of Materials and Labor on Numerous Engineering Works. By Halbert P. Gillette, Consulting Engineer, Member American Society Civil Engineers, Member American Institute Mechanical Engineers, late Associate Editor *Engineering News*. New York: Myron C. Clark, 13–21 Park Row. 1905. Pp. 610. 4 x 6½ inches. Price, $4.00 net.

This book can be highly commended to all having to do with construction work of any kind. Detailed records of cost of construction are comparatively seldom kept, and the average water-works superintendent, for instance, while he may know fairly well the total cost per foot of laying water pipes, has but a very hazy idea of the different items which go to make up that cost, and therefore can only guess at the effect of changes in conditions or of prices of certain supplies.

In the opening sentences the author says: "There are two principal objects in keeping itemized records of cost: (1) To enable the contractor or engineer to determine what will be fair unit prices for similar work in the future; and (2) to enable the contractor to analyze his expenditures with a view to improving his foremanship, class of laborers, plant equipment, and the like." Both of these objects should appeal to the water-works superintendent, for he must frequently estimate the cost of extensions, and must also often stand in the position of contractor in carrying out such extensions with day labor.

It may be said without hesitation that Mr. Gillette has done a great service in preparing this exposition of the principles and methods of keeping detailed cost records; the data presented, relating to cost of work actually done, while valuable, are of much less importance than the suggestions relating to methods of keeping records and reducing costs. Indeed, sources of information in print are not very common, and usually give insufficient detail to be of much use, so the author had comparatively little to draw upon outside of his own wide experience. It is gratifying to note that a portion of the more valuable information given by the author has been obtained from papers read before this association.

TRADE PUBLICATIONS.

ALLIS-CHALMERS COMPANY, MILWAUKEE, WIS. — Pumping Engine Department.

Bulletin No. 1600, July, 1905. — Test and Record of the 30 000 000-Gallon Pumping Engine Installed in the Chestnut Hill High-Service Station of the Metropolitan Water Works, Boston, Mass. 8 x 10½ inches, 11 pages, 3 illustrations.

Bulletin No. 1601, July, 1905. — Test of One of the 15 000 000-Gallon Vertical Triple-Expansion Pumping Engines Installed in the Baden High-Service Station of the St. Louis, Mo., Water Works. 8 pages, 2 illustrations.

Bulletin No. 1602, September, 1905. — Centrifugal Pumps, Operated by Simple, Compound, or Triple-Expansion Engines. 8 pages, 2 illustrations.

Bulletin No. 1603, August, 1905. — Reynolds Triple-Expansion Pumping Engines. 4 pages, 1 illustration.

Bulletin No. 1605, September, 1905. — High-Duty, Horizontal, Double-Acting, Crank and Fly-Wheel Plunger Pump, Driven by Cross-Compound Reynolds Corliss Engine, Standard Type F. M. P. 8 pages, 4 illustrations.

Bulletin No. 1606, September, 1905. — Multi-Stage, High-Lift Centrifugal Pumps, Motor Driven. 8 pages, 3 illustrations.

Bulletin No. 1607, September, 1905. — High-Duty, Horizontal, Double-Acting, Crank and Fly-Wheel Plunger Pump, driven by Cross-Compound Reynolds Corliss Engine, Standard Type F. O. P. 8 pages, 3 illustrations.

Bulletin No. 1608, September, 1905. — Single-Stage Centrifugal Pumps, Motor Driven. 4 pages, 1 illustration.

LOCK-BAR STEEL PIPE. The East Jersey Pipe Company, 71 Broadway, New York, N. Y. 9 x 6 inches, 34 pages, 2 diagrams, 13 illustrations.

RAYMOND CONCRETE PILING. Raymond Concrete Pile Company, Chicago, Ill. 6 x 9 inches, 48 pages, 31 illustrations.

NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XX. June, 1906. No. 2.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

ENGINEERING CONSTRUCTION BY THE UNITED STATES RECLAMATION SERVICE.

BY M. O. LEIGHTON, CHIEF OF THE DIVISION OF HYDRO-ECONOMICS,
UNITED STATES GEOLOGICAL SURVEY, WASHINGTON, D. C.

[*Read January 10, 1906.*]

There is a development going on in the West which many well-informed men believe to be of more importance to this country than the construction of the Panama Canal. Throughout the West there are thousands of people who have fought for its initiation and, having been successful, are now looking forward to its completion, and predicting, as a result thereof, the most remarkable era of advancement and prosperity that this country has ever beheld. In the East there is a bare handful of people who appreciate and understand; a few more have a vague, mistaken idea; but the vast majority of Americans east of Missouri River have no more information concerning it than they have with reference to the foreign policy of the King of Siam.

It has not been observed that this dearth of information upon the part of eastern people is confined to any one class or profession, and it has been a matter of surprise to find that so few eastern engineers, and especially those who have specialized in water-works construction, maintenance and operation, have thought it worth the effort to inform themselves concerning the greatest water-supply systems of the world, which are being constructed within their own country and which involve the expenditure of over thirty millions of dollars. This water-works construction is designed to change enormous areas in the Great American Desert from places of desolation and whitened bones to places of prosperous homes and fertile fields, where millions of people will dwell, and where generations of Americans will grow up. It involves engineering projects in many respects unprecedented in magnitude, which have quietly and conservatively, but none the less quickly and definitely, been entered upon, and are even now in process of construction.

Two fifths of the area covered by the United States is arid. This statement means that upon that proportion of all our possessions exclusive of Alaska and insular territory, sufficient rain does not fall to make agriculture profitable. Some of this area is in the semi-humid belt, where there may be for a season rain enough to provide for the growth and maturity of a crop, but where, perchance, the season or successive seasons following will bring little or no moisture. Some of it is desert, extending mile upon mile in blinding white solitude without the semblance of a living thing. Some of it is wind-swept plain, as level as the ocean and quite as featureless, differing from the desert only by reason of its growth of hard, dry, woody grass, its knots of sage-brush, its mesquite bushes or its cacti. There is upland and mountain, canyon and mesa, and all is devoid of useful vegetation as the paved streets of an eastern metropolis. This barren principality is greater than the empire of ancient Rome, seven times as large as the domain of the German Emperor, and equal to thirty states of the size of New York. Much of this region must always remain in its present condition, but there are enormous tracts throughout the length and breadth of the arid belt which retain every requisite feature of climate and fertility save that of moisture.

On June 17, 1902, the United States Congress passed the Reclamation Law. It provides that all the moneys received from the sale of public lands shall be set apart for the construction of irrigation works. The experience of years had shown that it was the only possible means whereby millions of acres of desert waste could be made habitable, and upon which there might develop communities which would return to the country an added vigor and stability which would be a thousand fold more valuable than the money expended. In addition to this, it seemed especially fitting that the money received from the sale of public lands should be expended in this way, because nearly all government land in the humid regions has been sold, and practically all that now remaining in government ownership is arid. The money so provided is not a gift to the arid belt, but a loan that draws no direct interest. The farmer who takes up public land in an irrigated area must pay for the cost of the irrigation system, or his proportionate part thereof. The payment must be made in ten annual installments without interest, and thus the Government is finally reimbursed for the actual expenditures made necessary by the construction of irrigation systems, and loses in the end only the theoretical interest on the money so used. At the end of the period of payment, the farmer is the sole owner of the water rights; they become appurtenant to his property. The law makes it one of the duties of the Secretary of the Interior to make examinations and surveys for appropriate irrigation works and to locate and construct them. He is further authorized to withdraw from entry all public lands which may be required for any system of irrigation, and also the land which may be irrigated from such system. The actual engineering work has been placed by the Secretary of the Interior under a corps of engineers which has been designated as the United States Reclamation Service.

A wise provision in the irrigation law is that which makes it necessary for the farmer to take up irrigated lands under the Homestead Act; that is, no single farm unit can consist of more than one hundred and sixty acres, and, to secure title, the farmer must be an actual resident upon the property.

This prevents enormous speculative operations by which companies or individuals with large capital may acquire tremendous tracts of lands, and thereby receive the benefits of government irrigation, to the exclusion of the individual provided with less initial capital. In other words, the terms of the statute were designed to provide for *homes* in the arid states, rather than to increase the values of the land for speculative purposes.

The location and the extent of the work already undertaken is set forth in Table No. 1. It will be seen that all of the states and territories represented in the arid belt are provided for with the exception of Oklahoma, in which reconnaissance work is now going on.

TABLE NO. 1. IRRIGATION PROJECTS ALREADY UNDERTAKEN.

State.	Name of Project.	Acres Irrigable.	Allotment.
Arizona	Salt River	160 000	$3 850 000
California	Yuma	85 000	3 000 000
Colorado	Uncompahgre	100 000	2 500 000
Idaho	Minidoka	60 000	1 300 000
”	Payette-Boise	60 000	1 300 000
Kansas	Garden City	8 600	260 000
Montana	Huntley	30 000	900 000
”	Milk River	——	1 000 000
Montana *(⅔)	Lower Yellowstone	40 000	1 200 000
Nebraska and Wyoming	North Platte	100 000	3 330 000
Nevada	Truckee-Carson	120 000	3 000 000
New Mexico	Hondo	10 000	240 000
”	Carlsbad	——	600 000
”	Rio Grande	——	200 000
North Dakota (⅓)	Lower Yellowstone	20 000	700 000
North Dakota	Pumping plants	33 000	1 000 000
Oregon	Klamath	100 000	2 000 000
”	Umatilla	18 000	1 000 000
South Dakota	Belle Fourche	60 000	2 100 000
Utah	Strawberry Valley	25 000	1 250 000
Washington	Okanogan	9 000	500 000
”	Yakima	40 000	1 750 000
Wyoming	Shoshone	75 000	2 250 000
		1 153 600	$35 230 000

* For dam in St. Mary; will not irrigate any land.

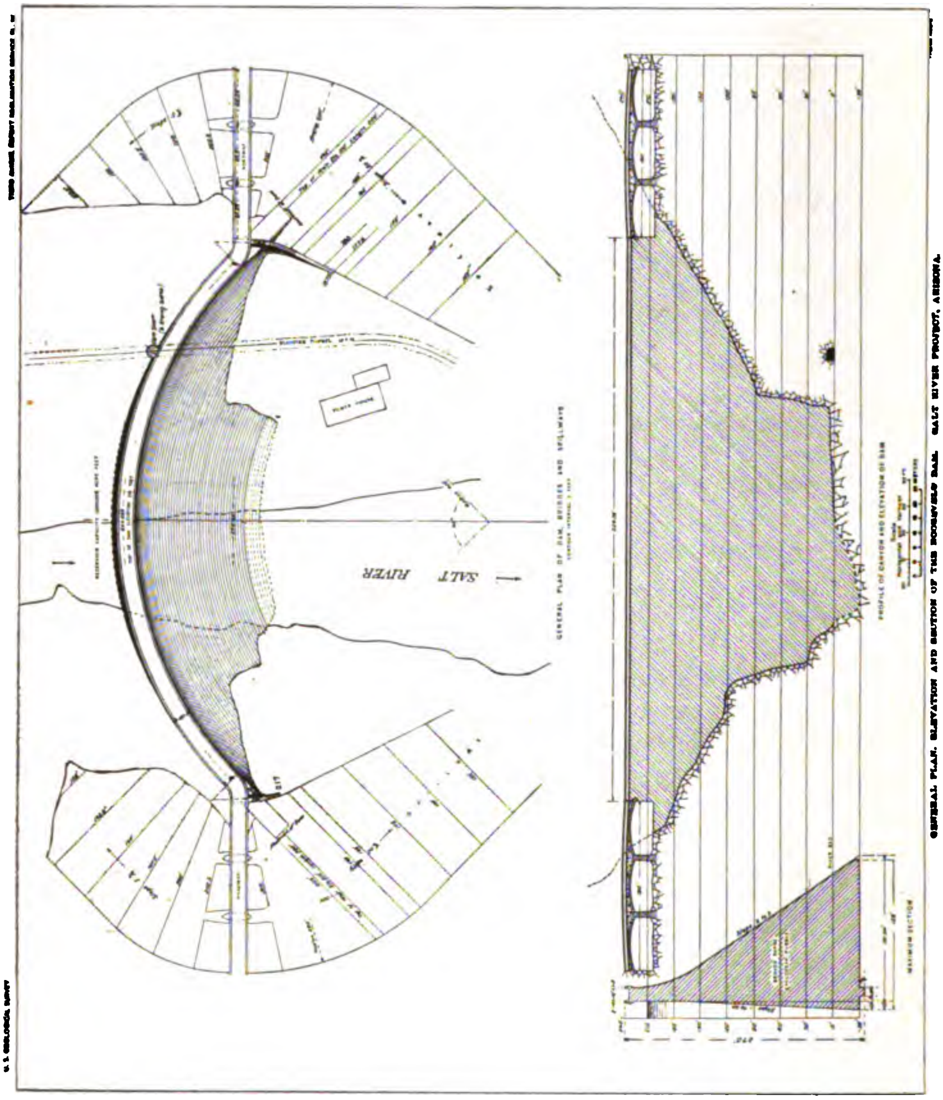
It will be impossible to discuss within the time allotted for this paper the constructive features of all the projects named in this table. Therefore attention will be given to those which comprise the most interesting features.

SALT RIVER PROJECT, ARIZONA.

The area to be irrigated under this project lies in the lower valley of Salt River in the region about Phœnix, Tempe, and Mesa, while the storage reservoir, the largest artificial lake in existence, lies to the northeast about seventy miles from Phœnix. The water stored in the reservoir is to be released as required for irrigation and allowed to flow down the bed of the river to a point near the head of the irrigated area, where it will be diverted into properly constructed canals. About 160 000 acres in this lower valley will be irrigated under gravity canals, while the remainder will be provided for by pumping water on the higher levels with power derived from a plant located at the reservoir dam. The reservoir will cover what is known as the Tonto Basin, a great depression formed by the valleys of Salt River and Tonto Creek, the two streams joining a short distance above the dam site. (Plate I, Fig. 1.) The extreme length of this reservoir will be 25 miles, its greatest depth of water 230 feet, and its capacity 61 000 000 000 cubic feet, or about 456 000 000 000 gallons, sufficient to supply the Metropolitan water system in Massachusetts at the present rate of consumption for a period of ten and one-half years.

Salt River enters a canyon a short distance below the confluence of Tonto Creek. Across this canyon, at the section shown in Plate I, Fig. 2, a dam, known as the Roosevelt Dam, is in process of erection which will have a total height from foundation to top of parapet of 280 feet, and an effective storage height of 230 feet. (See Fig. 1.) The length of the dam at datum, or low water, will be 138 feet, and at the crest, 644 feet. The section of the dam provides for a masonry wall 158 feet thick at the base, tapering as indicated to a thickness of 16 feet at the crest. There will be about 300 000 cubic yards of masonry in the structure.

The dam has a gravity arch section, the radius being 400 feet. A roadway is carried over the dam, crossing the spillways on each side by concrete-steel arch bridges. The total height of the spillway above datum or mean low water will be 230 feet, while the roadway will be 20 feet higher. The spillways are each about 200 feet long, providing for a total discharge of 4 000 cubic feet per second. The specifications require that the masonry shall be of broken range cyclopean rubble, laid so as to break joints and be thoroughly bonded in all directions. The stone will be quarried from the walls on each side of the canyon for the spillways, and will be laid in cement mortar. The material is a tough, coarse-grained sandstone of a specific gravity of about 2.5. Samples of the stone crush at a pressure of from 1 000 to 1 800 tons per square foot, which affords an exceedingly wide margin of safety. The stone for the up-stream face will be selected so as to lie with horizontal beds and vertical joints in


SALT RIVER
GENERAL PLAN OF DAM, BRIDGES AND SPILLWAYS
POWER HOUSE
PROFILE OF CANYON AND ELEVATION OF DAM
MAXIMUM SECTION
U. S. GEOLOGICAL SURVEY

GENERAL PLAN, ELEVATION AND SECTION OF THE ROOSEVELT DAM. SALT RIVER PROJECT, ARIZONA.

FIG. 1.

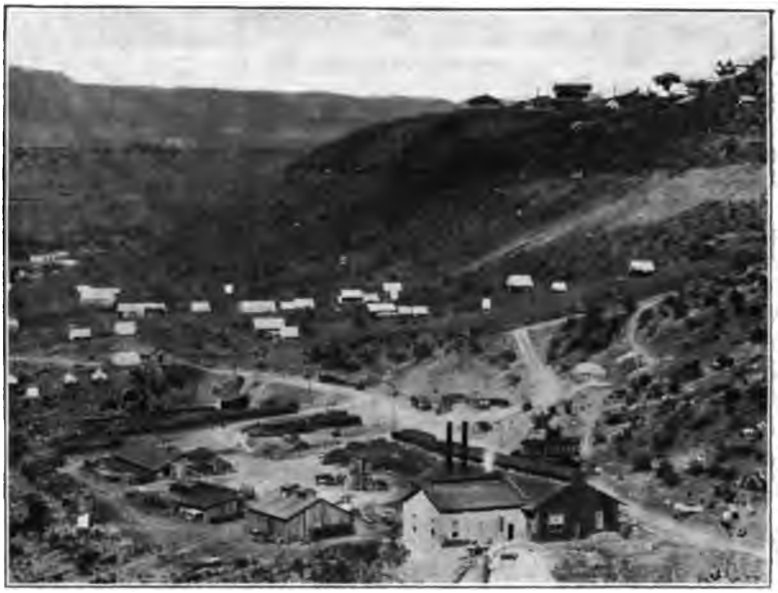


FIG. 1. TONTO BASIN (SALT RIVER), ARIZONA.

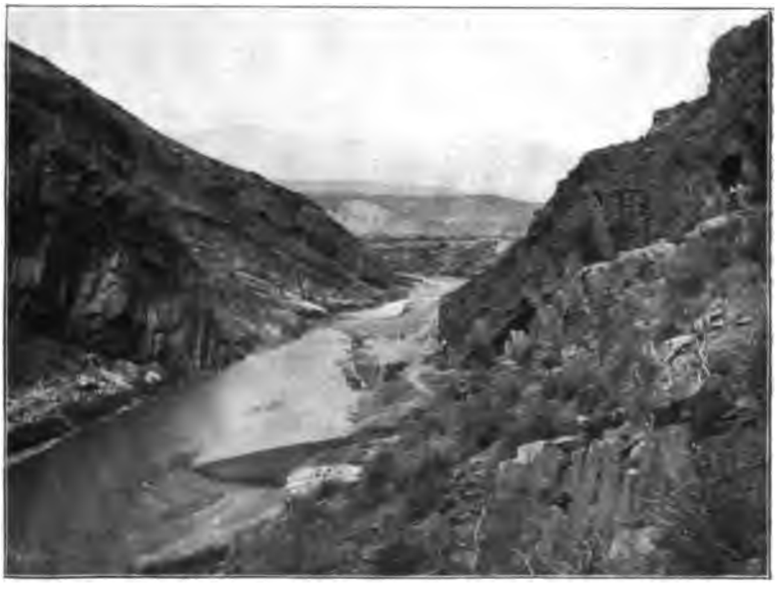


FIG. 2. SITE OF ROOSEVELT DAM (SALT RIVER).

Portland cement mortar composed of one part Portland cement and two parts sand. Vertical joints between the stones inside of the face of the dam must nowhere be less than six inches. The concrete used in the construction of the dam is composed of one part cement, two and one-half parts of sand and four parts of broken stone. The term "sand" is interpreted as the run of the crusher which passes a quarter-inch screen, while "stone" is interpreted as that which passes a two-inch mesh.

In order to provide for the rights of prior appropriators, it is necessary to guarantee the release of a certain amount of water into the river channel at all times. To accomplish this and to utilize the power available at the dam site, a low diversion dam has been constructed across Salt River above the upper reaches of the overflowed areas, and in seasons of low water the entire flow of the stream will be diverted around the reservoir by means of a conduit 19 miles long. A part of this conduit is in heavy cut, some of it on fill, while 9 000 feet consists of tunnels, 15 in number, through clay, sand, quicksand, and solid rock. Fourteen of these tunnels are along the power canal and one is a sluicing tunnel at the dam site.

Tunnel No. 1 at the point of diversion is 1 700 feet in length and afforded more difficulties of construction than any of the others. For 600 feet it passed through bowlders that were imbedded in quicksand and varied from small cobbles to masses weighing several tons. As this sand would run like water, heavy timbering was provided. The finished section of this tunnel has a width of 9 feet and a height of 8 feet to the apex of the arch, but in order to allow for the timbers the excavation was made 12 feet wide and 11 feet high. Square sets of 10-inch timbers were placed two feet apart from center to center and inside each of these an arched set was placed for extra strength as well as to give a proper section to the tunnel. The breast of the tunnel had to be boarded solid and the lagging driven ahead for each following set. The greatest difficulty occurred when big bowlders were encountered. These had to be dealt with separately and worked an inch at a time, regardless of size or condition, as any attempt to break them with powder would have caused a cave or a run. This 600 feet of bad ground was worked with four headings with 2 shifts each, and an average of 6 feet per day was made from the four headings.

Quicksand was encountered elsewhere in the work, but was not as difficult as at tunnel No. 1.

The last tunnel to be constructed was the penstock. This is a circular tunnel, 620 feet long and 8½ feet in diameter; it has a fall of approximately 200 feet from the mouth of the canal to the turbine. Before work was begun on this tunnel it was necessary to excavate, out of the perpendicular cliffs, a site for the power plant, which is 23 feet above the river. The tunnel starts at the back of the power plant at the elevation of the floor. Work was begun at the lower end of the penstock by hand, as floods in the river made the temporary power plant useless. For two months the materials and supplies were packed in on the shoulders of men, along precipitous canyon sides, shelving rock and rolling bowlders, and passed down the vertical cliffs by ladders and ropes. In this way 110 feet of the tunnel was driven. Later, after the floods had subsided, the work was carried on more expeditiously by means of power. Notwithstanding the fact that an exhaust fan with 7-inch piping was used, the heat and gas were intense. It is a peculiarity of this climate and elevation that all underground raises have no ventilation. In this tunnel the heat was unusual, due to the proximity of subterranean hot springs.

The sluicing tunnel around the base of the dam is 13 feet wide, 11 feet high, and 480 feet long, and it is carried through solid quartzite and sandstone. The heat here was intense and caused the death of two of the men; several hot springs were encountered and the temperature rose to 130° Fahrenheit, with practically 100 per cent. humidity.

The cost of the masonry construction of the dam is $3.15 per cubic yard, or a total for the entire structure of $1 147 600. This cost is exclusive of cement and sand, which are furnished by the Reclamation Service from the Government cement mill near the dam site, which will be described later. The total cost of dam, allowing $2.50 per barrel for cement, is over $2 000 000. The cost of the power tunnel was $26.50 per linear foot.

One of the best pieces of construction connected with the Salt River project is the sluicing tunnel and gates. (Fig. 2.) In

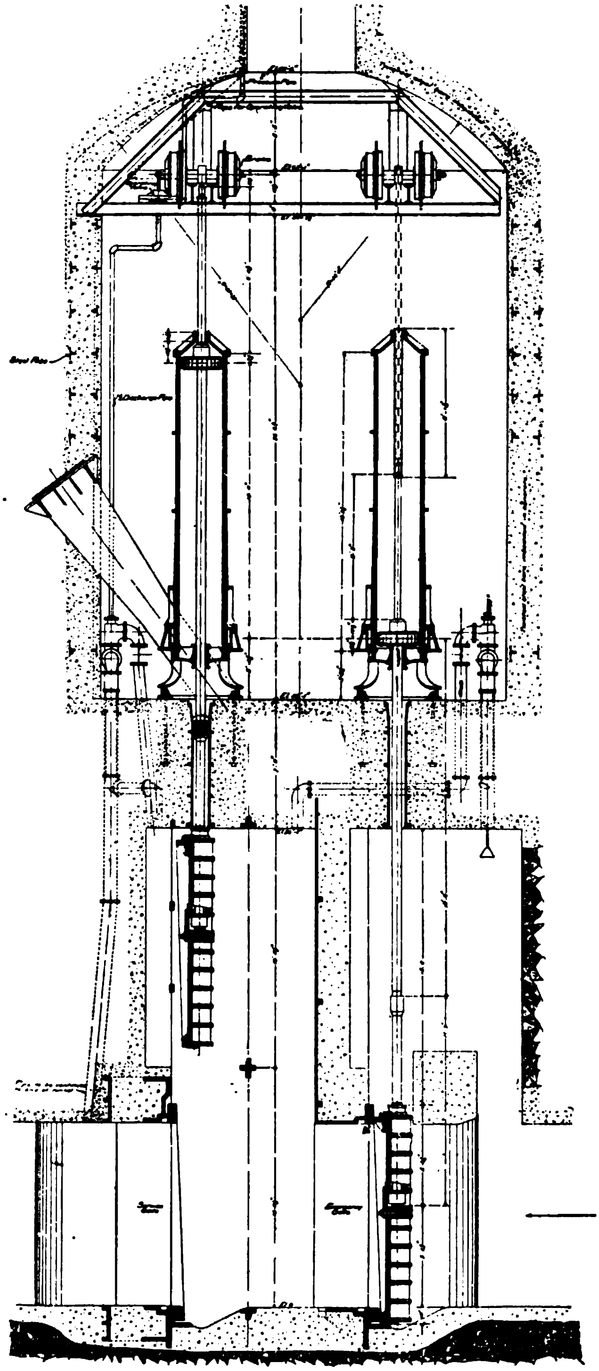


FIG. 2. SLUICING GATES AT ROOSEVELT DAM.

this tunnel will be placed six gates to be used for sluicing purposes and for regulating the flow of the water to the canals of Salt River Valley. These gates with their operating mechanism will weigh nearly 800 000 pounds, and will be the largest ever constructed to operate under the great pressure of 100 pounds per square inch. The pressure on each gate is about 800 000 pounds. With the reservoir full, these gates are capable of discharging 10 000 cubic feet per second. During the construction of the dam, the river will be diverted through this channel. It will not be possible in the time allotted for this paper to discuss the details of construction. Indeed, the subject is worthy of a separate paper.

One of the interesting features of this project is the Government cement mill, constructed near the dam site. It was not originally the purpose of the Reclamation Service to enter into the manufacture of cement, but it was found that the cost of cement shipped to this site would be prohibitive. The nearest railroad point is Globe, Ariz., which is not within easy access of any of the cement works. The freight rates to this terminal point are high, and the transportation overland for forty miles to the dam site would add excessively to the cost. The bids which were received for furnishing cement were $4.81 per barrel, delivered at the dam site. As the construction required 200 000 barrels of cement, the cost of the work would be prohibitive. It was found, however, that cement materials were available at or near the dam site; a good cement rock underlies the mill and suitable clay is available a short distance away. It was therefore decided to erect a mill, at a cost of $100 000. The cement manufacturers naturally objected to this move, but it was conclusively shown that if it were necessary to purchase cement at the price at which it could be delivered at the dam site, the cost of the structure would be wellnigh prohibitive, while the erection of the cement mill and the manufacture of the material upon the spot would result in an enormous saving. In view of the fact that cement manufactured at this mill costs $2.50 per barrel, the Government could hardly afford to haul purchased cement from Globe to the dam site, even if the material were delivered at Globe free of cost. The mill finally erected has a capacity of 350 barrels per day.

The chief item of expense is that of fuel, it being necessary to haul oil in wagons from Mesa, Ariz., a distance of about fifty miles. Average results of tensile tests of neat cement briquettes are: 478 pounds after seven days (one day in air and six days in water); 552 pounds after fourteen days.

The Uncompahgre Project.

The Uncompahgre Valley comprises an area in Ouray, Montrose, and Delta counties in the southwestern part of Colorado. It is watered by Uncompahgre River, which flows northward and joins Gunnison River at Delta. In this valley there are about 75 000 acres which early experience proved to be exceedingly fertile under irrigation. (Plate II, Fig. 1.) Consequently, in about 1884 settlers flocked to the valley and filed upon nearly all the land in the region. Irrigation canals were constructed and what was believed to be a mighty era of prosperity was begun. It was soon found that all this development was made without any idea of the amount of water in Uncompahgre River available for irrigation. The river did not begin to furnish sufficient supply. After a time great tracts were deserted, costly improvements abandoned, and the acres under cultivation soon dwindled to 30 000.

Thirty miles eastward from Uncompahgre River and flowing nearly parallel to it is the Gunnison (Fig. 3), which farther to the north takes an abrupt westward turn and is joined by the Uncompahgre at Delta. Along this portion of the Gunnison parallel to the Uncompahgre, the river traverses the Grand Canyon (Plate III, Fig. 1), one of the best scenic features of the West, and at the same time one of the most difficult places of access.

The method of solution of the Uncompahgre problem which found most favor was the tapping of the Gunnison by a tunnel opening at the bottom of this canyon and extending underground six miles to a point in the Uncompahgre Valley from which the water could be carried in open canals. Up to the time of the official investigation nothing was known concerning Gunnison Canyon save that its walls rose sheer 3 000 feet, that a torrential stream ran through the bottom, and that it was impassable. So far as was known, no man had ever passed through this canyon alive. It was necessary to know, first, the conditions existing in the canyon and whether or not, were all the other difficulties overcome, it would be possible to open a tunnel heading. A voyage through the canyon was necessary, and

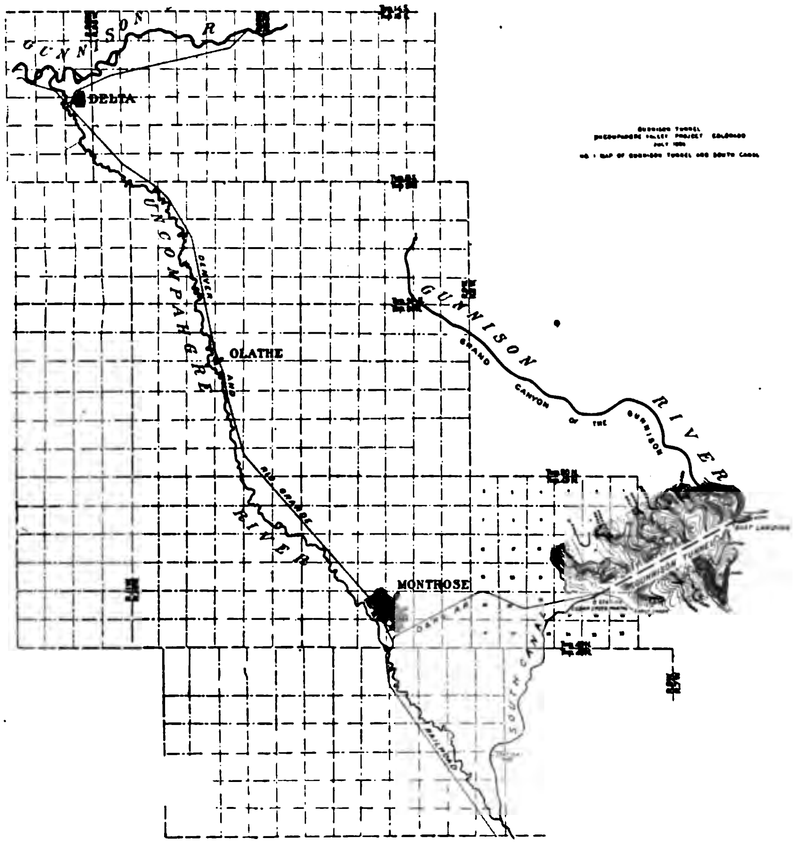


FIG. 3. MAP SHOWING LOCATION OF GUNNISON TUNNEL.

it was undertaken and accomplished by Mr. A. L. Fellows, at that time district engineer for Colorado. In spite of the difficulties and dangers attendant upon the journey, Mr. Fellows' observations resulted in the selection of a heading just above the point at which the canyon boxes up.

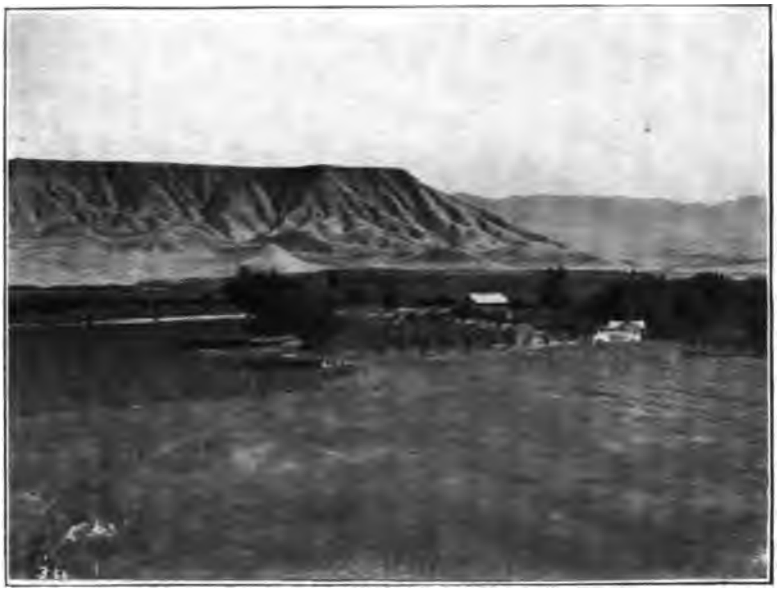


FIG. 1. UNCOMPAHGRE VALLEY UNDER IRRIGATION.

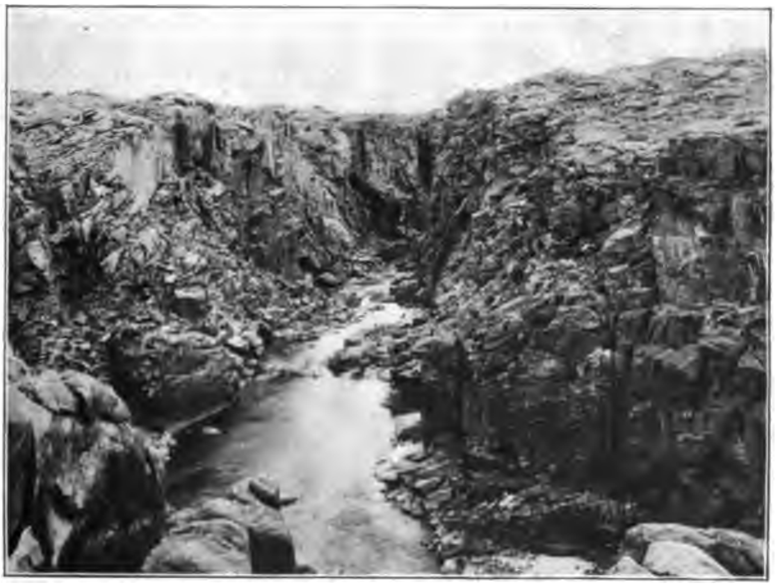


FIG 2. SITE OF PATHFINDER DAM (NORTH PLATTE RIVER).

PLATE III.

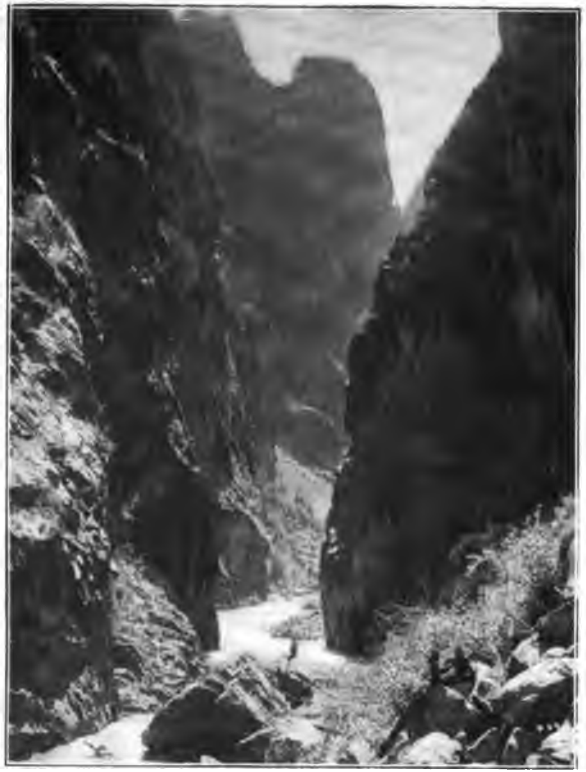


FIG. 1. CANYON OF THE GUNNISON.

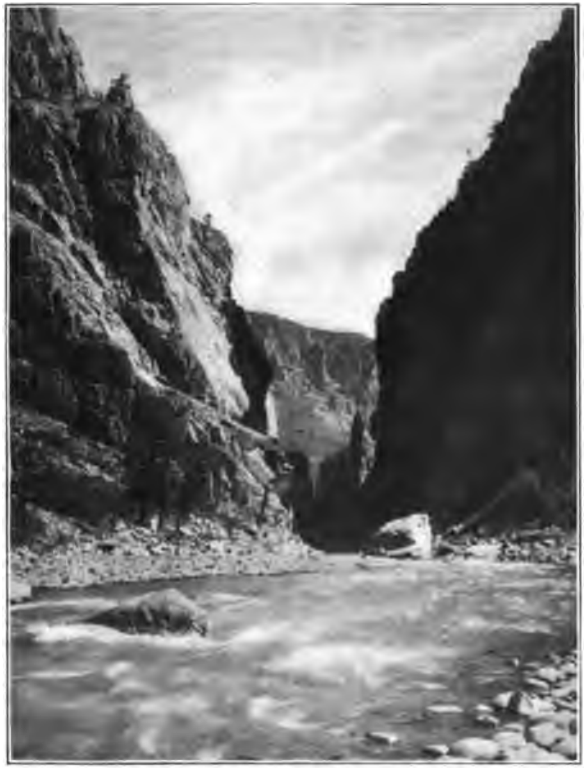


FIG. 2. SITE OF SHOSHONE DAM.

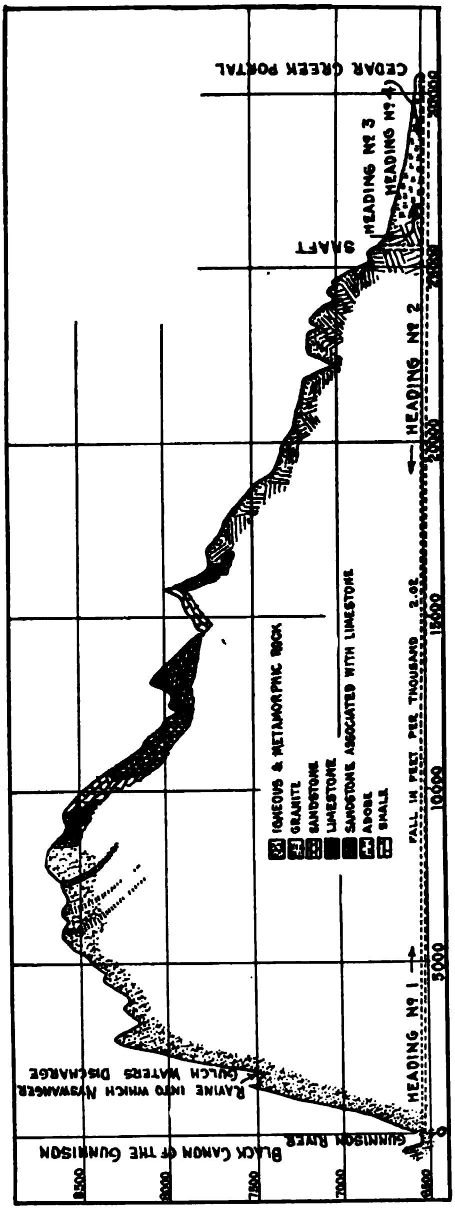


Fig. 4. Profile of Gunnison Tunnel.

In Fig. 4 is shown the tunnel profile. When finished it will be 30 582 feet long, and of a capacity of 1 300 cubic feet per second. The total excavation will be 183 500 cubic yards, of which 93 000 cubic yards will be in rock. The total amount of lining will be 30 000 cubic yards, laid at a cost of $6.75 per cubic yard. The cost of the tunnel and other rock is $40 per linear foot, while the total cost of the tunnel will be $1 200 000.

North Platte Project.

The land to be irrigated under the North Platte project lies in southeastern Wyoming and western Nebraska along the North Platte River Valley, as shown in Fig. 5; the total acreage irrigable will be 100 000. The water is to be conserved in the Pathfinder reservoir, and, being discharged from there, will flow sixty miles in the stream bed and then be diverted into the Interstate Canal, which conducts the water into the area in question. The point of interest in this project from the engineering standpoint is the Pathfinder Dam and appurtenant works.

The dam called the Pathfinder Dam is located across the channel of North Platte River in Wyoming, three miles below the mouth of Sweetwater River, where the Platte enters the canyon cut through Rattlesnake Range. (Plate II, Fig. 2.) Here the gorge is 80 feet wide at low-water mark and but 180 feet wide at a point 160 feet above Datum. The walls are of solid granite, and bed rock without seam or fracture occurs 10 feet below low-water mark. Fig. 6 shows a cross-section of the gorge with dam in place, and a cross-section of the dam which is being constructed of granite in broken range cyclopean rubble. The total amount of masonry will be 53 000 cubic yards. The specifications provide that the masonry shall be laid so as to break joints and thoroughly bond the work in all directions. The stone used is as large as practicable, and facilities are provided for handling stones weighing ten tons. The aim is to use in the construction

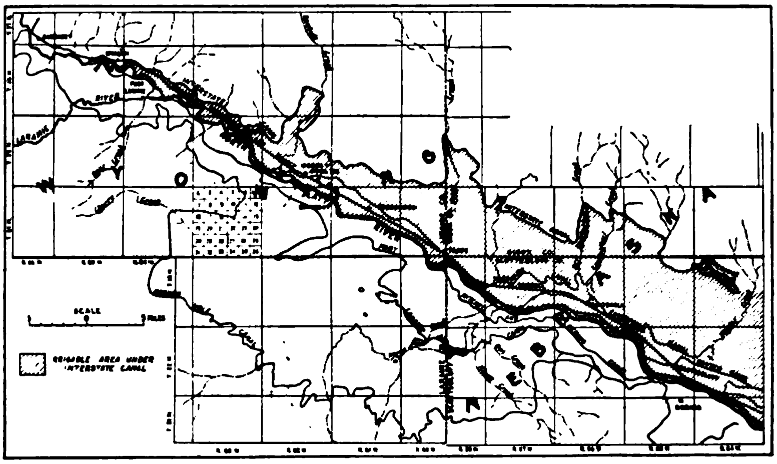


FIG. 5. MAP SHOWING INTERSTATE CANAL, NORTH PLATTE PROJECT.

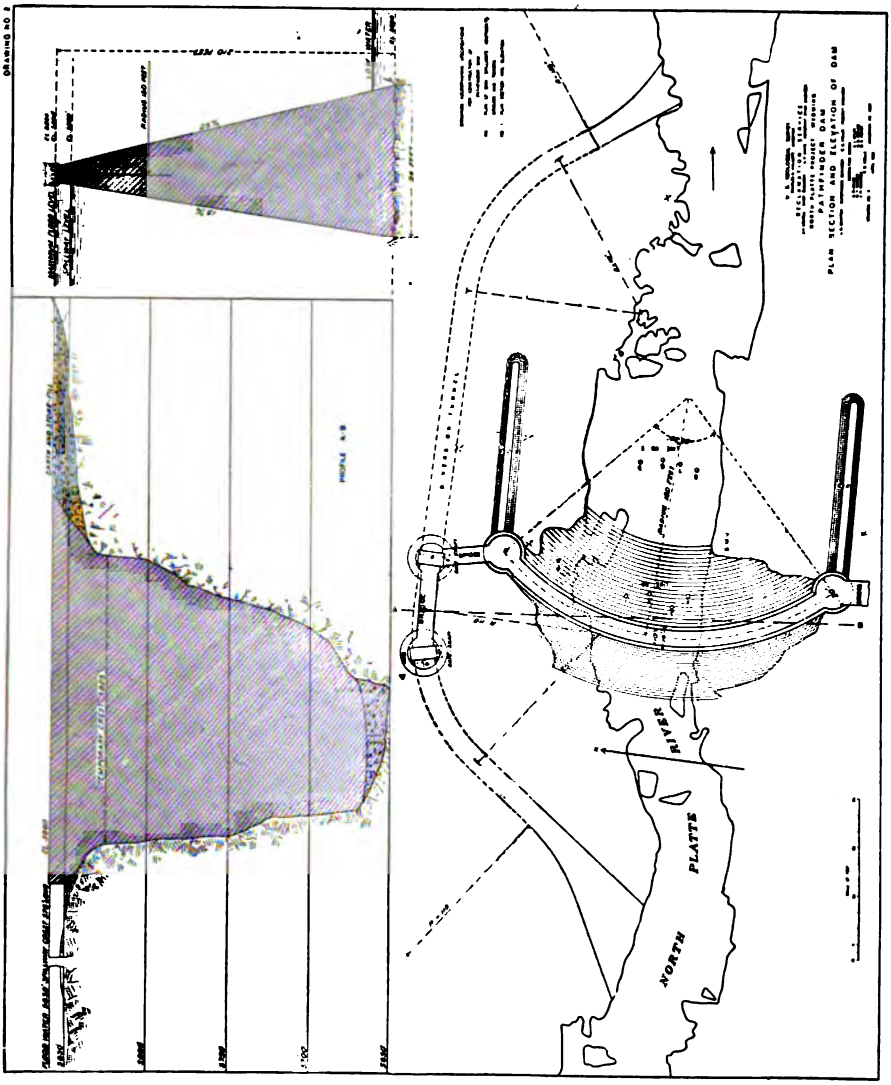


Fig. 6. Pathfinder Dam.

of the dam the largest proportion of stone and the smallest proportion of mortar and concrete. The stone for the up-stream face is selected so as to lie with horizontal beds and vertical joints in Portland cement mortar composed of 1 part cement to 2 parts sand. At least one fourth of the area in the face must be headers, evenly distributed throughout the wall, and every header must be laid over a stretcher of the underlying course. The stretchers must not be less than 3 feet long nor less than 2 feet in any other dimension. The headers must not be less than 6 feet in length nor less than 2 feet in any other dimension. The stone for the down-stream face is selected so as to lie with horizontal beds and vertical joints in cement mortar composed of sand and cement in the proportion of 1 part cement to 2½ parts sand, where not otherwise directed. At least one fourth of the area in the face must be headers. All concrete used in the dam is composed of the proportion of 1 part cement and 2½ parts sand and 4 parts of broken stone of such size as to pass through a 2-inch mesh screen. Sand in this case is considered that part of the run of the crusher passing a ¼-inch screen.

The dam (Fig. 6) is of arch type, constructed on a radius of 150 feet. It is 10 feet thick at the crest, 94 feet thick at the base, and 210 feet high. The batter of the up-stream face is 0.15 and of the down-stream face, 0.25. The masonry is reinforced by steel rails at points at and below the crest where special horizontal and vertical stresses will develop.

In may be considered by some that this dam is of very thin section, but it conforms to the principles established by a long series of elaborate experiments made under the direction of the board of consulting engineers of the United States Reclamation Service, the work being executed under the immediate direction of Mr. George Y. Wisner, a member of the Board. For a discussion of these experiments see *Engineering News*, issue of August 10, 1905, p. 141 *et seq.*

The maximum depth of water behind Pathfinder Dam will be 200 feet, and the amount of water stored will be 326 000 000 000 gallons. The contract price for the complete structure is $582 000. As will be noted upon the plan, the outlet of the reservoir will be through a tunnel cut through the walls of the canyon, and through this the river is diverted during construction. The spillway is provided on the right bank of the canyon so that the dam is a solid structure without gates or openings, and no water will flow over the top.

THE SHOSHONE PROJECT.

This project contemplates the storage and diversion of a portion of the surplus water of Shoshone River in Wyoming for the reclamation of public lands lying on the north side of the river, extending from the mouth of the Shoshone Canyon down stream about 50 miles, covering an area of approximately 282 000 acres. The present development is proposed to reclaim only 125 000 acres. Just below the junction of its two forks, Shoshone River enters a canyon 3 miles in length, 1 mile of which is cut in solid granite with nearly vertical walls, and it is about 65 feet wide in its narrowest places. The point selected for the dam site (Plate III, Fig. 2) is 70 feet wide on the bottom of the channel and 200 feet wide at an elevation of 240 feet, the proposed height of the dam above the river bed. (Fig. 7.) This provides for a dam of a height from lowest foundation to capstone of from 305 to 310 feet, it being the highest dam in the world, both in total height and effective storage height. The capacity of the reservoir formed thereby will be 14 858 000 000 gallons, or a little less than one half of the storage capacity afforded by the Pathfinder Dam and a little more than one third that afforded by the Roosevelt Dam. The spillway will be 250 feet in length, the weir being located a few hundred feet below the dam on the side of the canyon, and connection therewith from the reservoir will be made by the construction of a spillway tunnel of a capacity of 10 000 cubic feet per second.

A tunnel for the public highway will be cut out of the same side of the canyon and will cross this spillway tunnel twice at an elevation of about 45 feet above the average elevation of the spillway tunnel floor. The dam as shown in the illustration will be of the arch type upon a radius of 150 feet. (Fig. 8.) It will be noted that the dam is being constructed 108 feet thick at the base and 10 feet thick at the crest, with an up-stream batter of 15 per cent. and a down-stream batter of 25 per cent.

As shown upon the illustration, a vertical section of the dam having an effective storage height of 31 feet will be constructed in advance of the main portion for the purpose of diverting water from the excavation. The section of this dam is based upon experimentation in the same way as has been discussed in the case of the Pathfinder Dam, a thin section with an uncommonly large up-stream batter for this kind of structure.

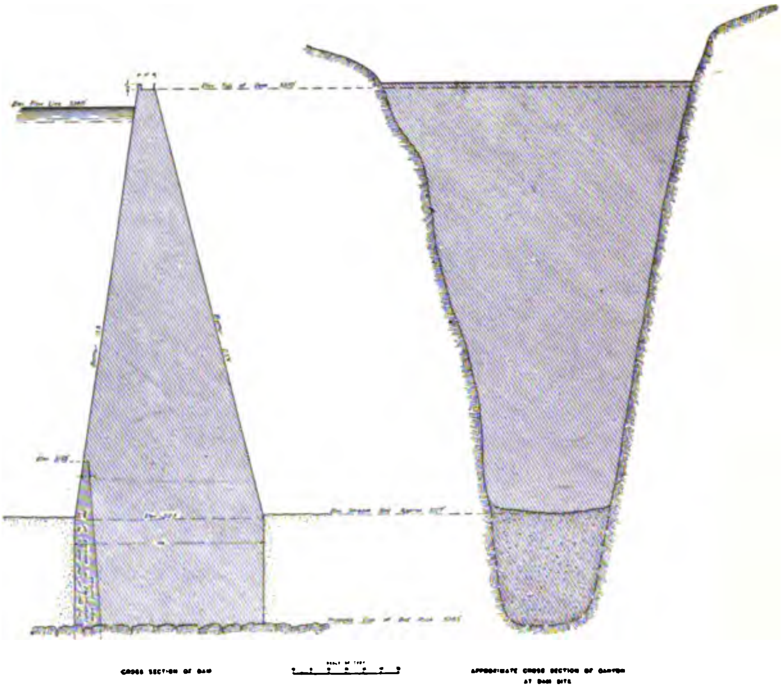


FIG. 7. SECTION AND ELEVATION OF SHOSHONE DAM.

The dam is being constructed of concrete of a composition, where not otherwise specified, in the proportion of 1 part cement, 2½ parts sand, and 5 parts of broken stone. The term "sand" is interpreted as that portion of the run of the crusher which shall pass a screen of ¼-inch aperture, the proportion of finer particles being such that the void in the dry aggregate shall not exceed 30 per cent. of the mass. The stone used in the crusher is granite taken from the sides of the canyon and other suitable places. The concrete will be reinforced by steel and iron rails in such portions of the dam as will by reason of horizontal and vertical stresses require such reinforcement. It is provided in the specifications that both faces of the dam shall be molded against forms of dressed tongued and grooved timber placed to conform to lines established by the engineer. The concrete shall be so placed against these forms and so manipulated as to secure a smooth, dense, and uniform facing of the dam. The contract further provides that in the freshly deposited concrete

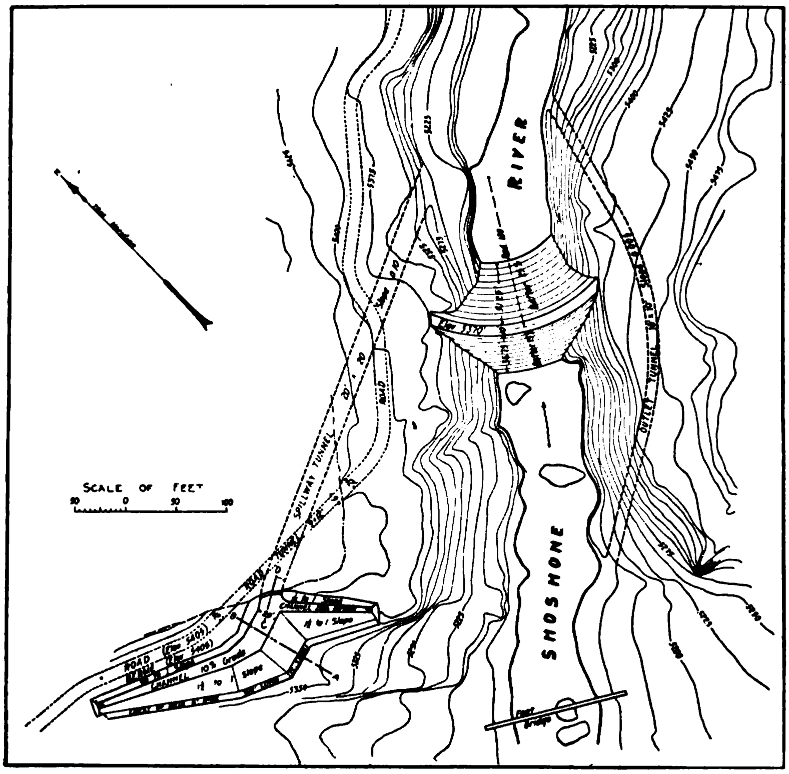


Fig. 8. Plan of Shoshone Dam and Tunnels.

the contractor shall place by hand pieces of granite weighing between 25 and 200 pounds, which shall be rammed until well bedded. The proportion of such rocks shall be as nearly as possible uniform throughout the dam and shall form at least 25 per cent. of the total volume of masonry. No such rock shall be in contact with any other or within 6 inches of either face or either abutment of the dam. The work will be done with three daily shifts of eight hours each, and the contractor is required to adopt means to provide such appliances and housing as will permit the construction of the masonry work during cold weather. Such provisions shall maintain the temperature within 6 inches of the concrete until it is ten days old at not less than 32° F.

There will be two outlet conduits leaving the reservoir, one at 10 and one at 60 feet above the river bed. The one leaving the reservoir at the elevation of 10 feet will be by a tunnel through the side of the canyon 500 feet in length and 10 by 10 feet in cross-section, and will discharge the water from the reservoir into the low-level canals.

The total cost of the Shoshone Dam, including outlet tunnel, spillway tunnel, spillway and road tunnel, will be $600 000. The cost and dimensions of the three masonry dams here described compared with similar figures for the New Croton and Wachusett dams are set forth in the following table:

TABLE NO. 2.

	Roosevelt Dam.	Pathfinder Dam	Shoshone Dam	New Croton Dam	Wachusett Dam
Length at crest	650	226	175	1 168	850
Height above foundation	280	210	308	297	207
Maximum effective storage height	230	190	240	157	185
Thickness at base	158	94	108	206	185
Thickness at crest	16	10	10	18	25
Cu. yds. of masonry	350 000	53 000	69 000	833 000	280 000
Capacity of reservoir (million cu. ft.)	61 000	43 560	19 863	4 000	8 400
Cost of dam	$2 000 000	$600 000	$700 000	$7 600 000	$2 000 000
Cost of dam per million cu. ft. stored	$32 80	$13 78	$35 25	$1 900 00	$238 10

It should be explained that the last entry upon this table does not represent the cost of storage per million gallons, but is based solely upon the cost of the dam. The total cost for storage in the Roosevelt basin, exclusive of power conduit and appurtenances, will be about $2 500 000, in which only about $85 000 is for land damages. In the case of the Wachusett Dam, the figure here given for cost per million gallons must be multiplied by about 4 to cover cost of entire reservoir.

Note. — The Belle Fourche Project and the large earthern dam to be erected in connection therewith are described in *Engineering News*, February 22, 1905, p. 210, and *Engineering Record*, March 3, 1905, p. 307.

DISCUSSION.

Mr. Charles W. Sherman. I should like to ask Mr. Leighton if he can tell us something about the run-off of those streams, and how much water they can depend upon collecting per square mile of drainage area, or something of that kind.

Mr. Leighton. The run-off at some of the principal arid land stations is as follows:

Table No. 3. Run-off of Rivers in the Arid Region — For the Year 1904.

Stream.	Station.	Second Feet per Sq. Mi.	Depth in Inches.	Drainage Area Sq. Mi.
Salt River	Roosevelt, Ariz.	.057	.785	5 756
Verde River	McDowell, Ariz.	.062	.843	6 000
Colorado River	Yuma, Ariz.	.062	.844	225 049
Gunnison River	Cory, Col.	.328	4.47	5 233
Humboldt River	Palisade, Nev.	.109	1.48	5 014
" "	Oreana, Nev.	.021	.288	13 800
Truckee River	Vista, Nev.	1.30	17.72	1 519
Carson River	Empire, Nev.	.737	10.02	988
Rio Grande River	San Idlefonso, N. Mex.	.071	.972	14 050
North Platte River*	Mitchell, Neb.	1.113	1.208	24 400
Milk River	Malta, Mont.	.028	.374	14 044
Shoshone River	Cody, Wyo.	1.28	17.44	1 480
Yellowstone River	Livingston, Mont.	1.286	17.523	3 580
Snake River	Minidoka, Ida.	.559	7.61	22 600
Palouse River	Hooper, Wash.	.382	5.20	2 210

* Eight days in January; sixteen in February; five in March, not included.

It may be of interest to compare the run-off of some of these rivers with some in the East.

TABLE No. 4. COMPARISON OF RUN-OFF OF RIVERS FOR THE YEAR 1904.

Stream.	Station.	Second Feet per Sq. Mi.	Depth in Inches.	Drainage Area Sq. Mi.
Yellowstone River	Livingston, Mont.	1.286	17.523	3 580
Connecticut River	Orford, N. H.	1.32	16.41	3 305
Palouse River	Hooper, Wash.	.382	5.20	2 210
Hudson River	Ft. Edward, N. Y.	1.97	26.74	2 800
Shoshone River	Cody, Wyo.	1.28	17.44	1 480
Mohawk River	Little Falls, N. Y.	2.27	30.96	1 306
North Platte River	Mitchell, Neb.	1.113	15.208	24 400
Susquehanna River	Harrisburg, Pa.	1.350	18.320	24 030
Verde River	McDowell, Ariz.	.062	.843	6 000
James River	Cartersville, Va.	.734	9.980	6 230

MR. FRANK L. FULLER. I should like to ask with regard to the evaporation from those lakes.

MR. LEIGHTON. That is one of the very important questions with which the Reclamation Service has to deal. Especially in the southern country, like Arizona, the evaporation is enormous,

TABLE No. 5. EVAPORATION FROM WATER SURFACE, IN INCHES.

	Arizona, 1890.	Yuma, Ariz., 1904.	Sweetwater, Cal., Dam, 1898.	Lake Tahoe, Sierra Nevada Mts., Cal., 1901.	El Paso, Texas, 1890.	Santa Fé, N. M.	Salt Lake City.
January	3	3.6	1.747	0.84	2.0	3.0	1.8
February	4	3.9	2.671	0.70	2.0	3.4	2.7
March	6	6.19	4.249	0.77	7.0	4.2	3.6
April	7	9.37	5.351	1.25	7.3	6.8	7.2
May	10	9.94	5.611	2.42	10.8	8.8	6.9
June	11	10.11	7.193	3.35	11.7	12.9	8.9
July	12	10.19	8.153	——	9.6	9.2	9.2
August	13	7.87	8.141	6.50	7.6	9.8	10.7
September	10	6.38	7.239	4.12	—	6.6	9.6
October	6	7.02	4.999	2.65	—	6.7	6.5
November	5	4.41	4.012	2.09	3.7	5.7	5.0
December	4	1.91	.867	1.44	3.0	2.7	2.3
Total	91	80.89	60.233	*26.13	—	79.8	74.4

* Eleven months.

and it becomes an important item in calculating the amount of water available from storage. The following figures may be of interest. Evaporation is given in inches per year from water surfaces.

Mr. Fuller. Can you tell us what the average rainfall is for a series of years?

Mr. Leighton. The United States Weather Bureau reports for 1904 the precipitations in arid regions as follows:

Table No. 6. Rainfall in the Arid Region, 1904.

	Precipitation for Year.	Departure from Normal.
El Paso, Texas	11.30	+1.96
Santa Fé, N. M.	14.19	—0.09
Phœnix, Ariz.	5.57	—1.38
Yuma, Ariz.	1.43	—1.55
San Diego, Cal.	6.61	—3.98
Spokane, Wash.	13 97	—4.35
Grand Junction, Col.	6.63	—1.90
Winnemuca, Nev.	9.44	+0.93
Salt Lake City, Utah	16.31	+0.07
Boise, Ida.	14.08	—0.40
Carson City, Nev.	10.52	—1.50

It should be stated with reference to the arid lands generally, that the precipitation, from an agricultural point of view, is not even as useful as would appear from the above figures, because in many places the rain comes in short periods and in great quantity, with long dry seasons intervening.

Mr. John C. Whitney. I should like to ask the speaker what the special object was of distributing those large fragments of granite throughout the concrete construction shown.

Mr. Leighton. Such construction is familiarly known as rubble concrete, or, in such structures as the Shoshone Dam where the stones are of large size, a more comprehensive term is cyclopean rubble concrete. The main object is to increase the weight of the dam and thereby increase its stability. The specific gravity of granite is greater than that of concrete. There is an important economic feature, too, in such construction, because the rock is usually cheaper than the cement materials and the cost of the structure is decreased by a proportionate amount. In all the contracts let by the Reclamation Service, cement is provided by the Government, and the contractor submits bids without taking cement into consideration. Therefore, you can readily see how advantageous it is to put large stone blocks into the structure, where rock is cheap. Twenty-five per cent. of the entire structure of Shoshone Dam will be of stone. As the formula for the concrete is 1 part cement, 2½ parts sand, and 5 parts stone, and there will be 70 000 cubic yards in the dam, it would require a little over 96 000 barrels of cement for the entire structure, if it were built of concrete, but, inasmuch as 25 per cent. of the dam will consist of stone, there will be saved 24 000 barrels of cement by using this method.

Mr. Sidney Smith. When the storms do occur, when the rain falls, do the streams not carry a large quantity of detritus, and has any arrangement been made to relieve the reservoir of that?

Mr. Leighton. They do carry enormous amounts. Some of the engineers who were working on Gila River used to state in a joking fashion, when they came back to Washington, that it was hard for them to distinguish between mud and water. By placing a stick upright in the material they could decide, because if it was mud the stick would stand up, and if it fell over, they knew it was water. (Laughter.) The fact that the streams do carry these great amounts of sediment presents another very perplexing problem for the Reclamation Service. Of course, the accumulation in a reservoir reduces the effective storage capacity. The Salt River reservoir, for example, will probably lose a large proportion of its capacity in, say, sixty years, and the reason for extending the dam 10 feet higher was to postpone the day when remedial measures would be necessary. In all such cases, there have been provided enormous sluicing gates, through which the accumulations may be removed. Ground sluicing may be necessary to clear the reservoir in a large measure of this sediment. Lake McMillan, in New Mexico, which is a reservoir built by a private company, has lost a very large percentage of its storage capacity, and that is not yet a very old reservoir. But in every case, as I say, provision for sluicing is made. It may be necessary once in a generation and the cost will be high, but such cost will be insignificant in proportion to the benefits of the reservoir and of the irrigation system, so that the property will easily afford the expense.

MR. SMITH. Will the cleaning out of the reservoirs at such times involve an expense to the owners of the land who use the water?

MR. LEIGHTON. Yes, sir. In ten years the property goes into the hands of the farmers, or, more correctly, into the control of the Water Users Associations, and they will maintain it thereafter. Those expenses will be provided for probably by the establishment of a sinking fund.

MR. FULLER. I should like to ask Mr. Leighton if it is necessary that this water, as it is used for irrigating, shall be reasonably free from sediment, or what the fact is with regard to it?

MR. LEIGHTON. No. If the sediment is properly handled, if it is merely what we call silt, it is a benefit to the property. You see the great portion of that country is sand, gravel, and coarse material, which is benefited by these deposits of silt. Take the Colorado River, for example, that is in a good many ways exactly similar to the Nile in its annual inundations and deposits of silt, and it has made the barren sand so rich that one farm hand cannot take care of more than 10 acres of land, because the crops grow so fast. They are raising all sorts of tropical fruits and have had considerable success lately with date palms, pomegranates, figs, almonds, and such things.

THE PITOMETER AND ITS USES.

BY EDMUND M. BLAKE, CIVIL ENGINEER, BOSTON, MASS.

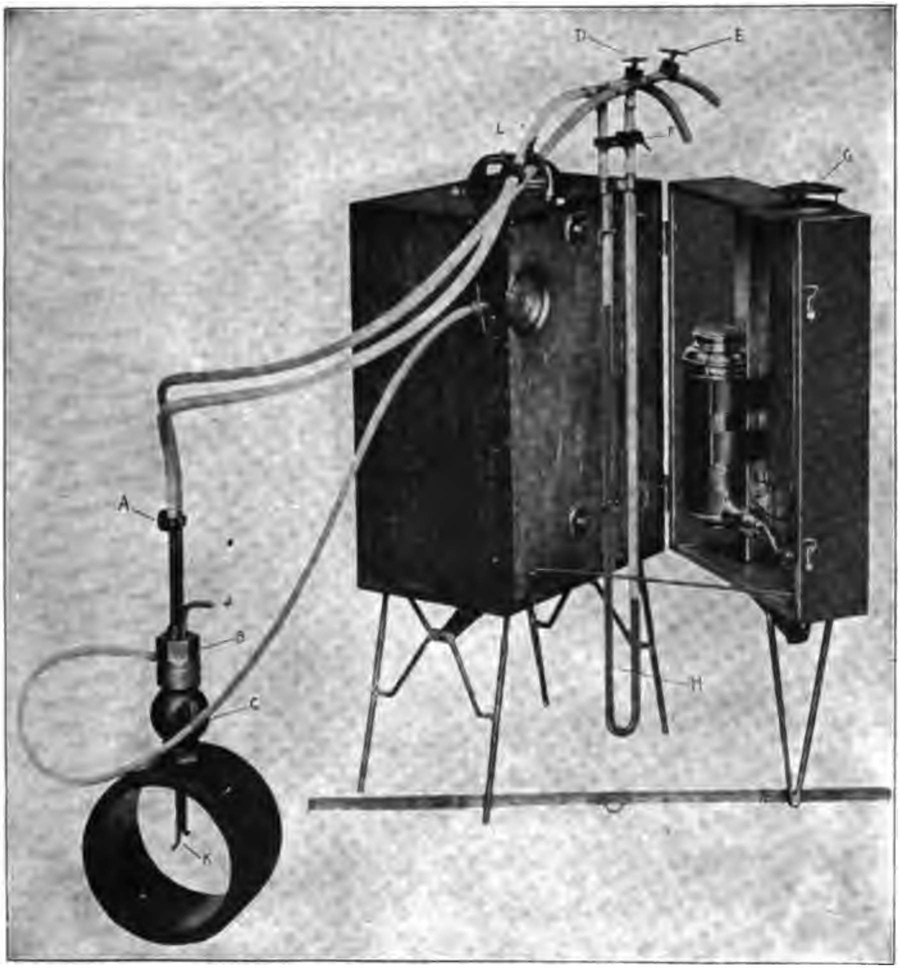
[*Read March 14, 1906.*]

In 1896, John A. Cole, consulting engineer of Chicago, found it necessary to make a water-waste survey at Terre Haute, Ind. He decided that it would be advisable to find some more economical method of measuring the waste flow than by use of the Venturi or Deacon meter. Edward S. Cole, associated with his father, finally acted upon a suggestion obtained from Prof. R. C. Carpenter's work on "Experimental Engineering," regarding the Pitot tube as applied to water mains. The use of the Pitot tube in open stream work is doubtless familiar to all engineers and superintendents.

Mr. Cole had to contend with many difficulties in adapting this principle to the measurement of velocities in closed pipes. Two tubes were finally adopted which could be introduced through a 1-inch corporation cock by means of a special cap, each tube with a hook bent 90 degrees and provided with a "cut-water." The two points of contact with the current are called orifices — one points down stream and the other up stream, as shown in Fig. 1. Many long series of calibrations were made with orifices and tubes of various diameters, but finally a choice was made of an orifice having an internal diameter of ⅛-inch, made of 3-16-inch brass tubing, fitted to ¼-inch tubes. It was found that an orifice and tube of this size gave more reliable indications at low velocities, and that there was less trouble with negative readings or failure to return to equilibrium at no flow.

A glass U-tube, 22 inches long and having an internal diameter of $\frac{5}{16}$ inch, was used. Connections were made by ¼-inch rubber tubing, and a blow-off was located at the top of each connection to remove air. The lower half of the U-tube was filled with a mixture of carbon tetrachloride and gasoline, with a specific gravity of 1.25 or 1.50 at ordinary temperatures. For high

PLATE I.



THE PITOMETER WITH PHOTO-RECORDER.

velocities mercury is used. Careful notes were made of the temperature at which observations were taken, and temperature corrections were applied where found necessary. Plate I shows a complete pitometer set up, with the " orifices " in position in a section of water pipe.

It was found that photography was the only practicable means of registering continuously the deflections in the U-tube, without interfering with those deflections. The photo-recorder combines, upon one photographic diagram, a record of the static variations within the pipe with a record of the U-tube deflections, the latter, of necessity, being half deflections, as shown on the U-tube. The instrument has shown itself capable of producing a good continuous record upon ordinary Velox paper. Plate II is a sample of such a record. Notches in the slit through which the light passes on its way to the paper are so located that they produce horizontal rulings upon the record, corresponding to the calibrated deflections taken from the curves (Fig. 2). The combination of static pressure variation with velocity aids in interpreting the cause of any given variations in the flow.

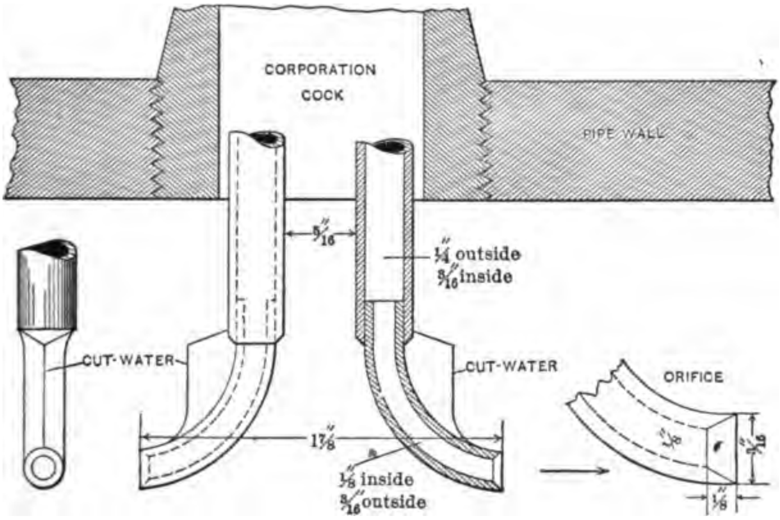


FIG. 1.

It is first necessary to ascertain, by an operation called a "traverse," the relation between the average velocity in the main and the highest velocity, which is usually at or near the center. This

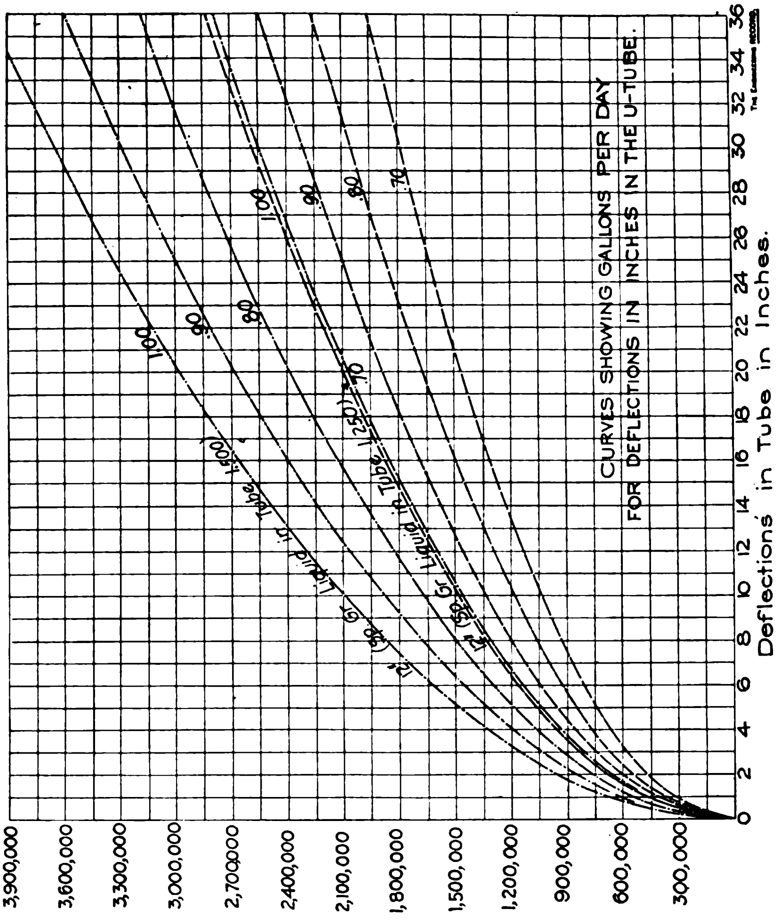


FIG. 2. CURVES SHOWING RELATION BETWEEN DEFLECTION IN U-TUBE AND QUANTITY OF WATER FLOWING.

relation varies considerably, according to the age of the main and the material of which it is made. When this relation — called the coefficient of the pipe — is ascertained, the orifices are

PLATE II.

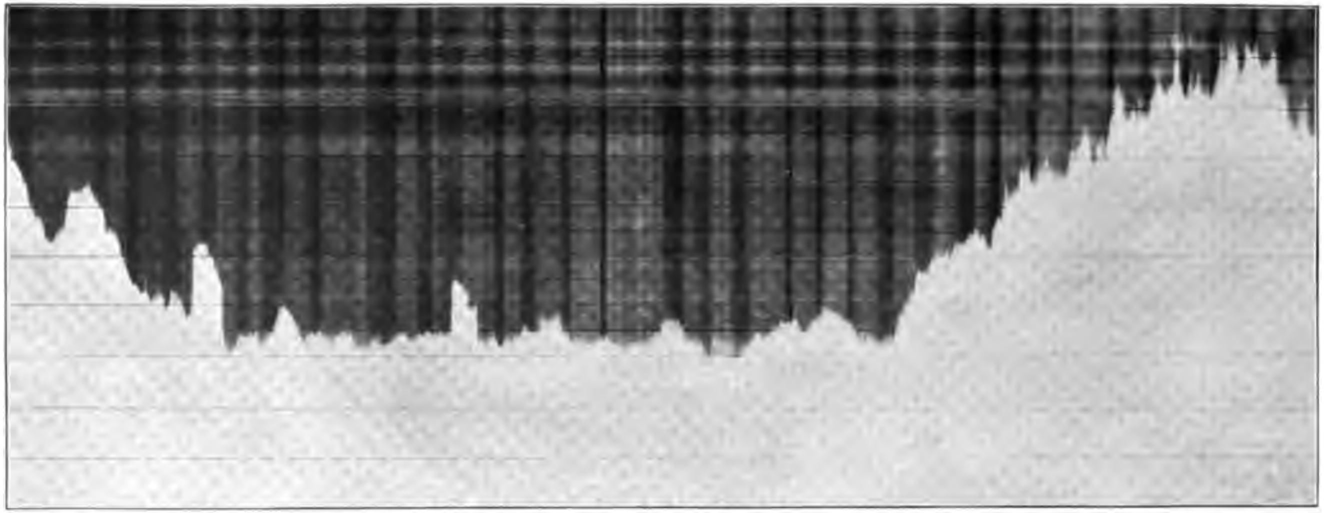


PHOTO-RECORD OF THE CONSUMPTION IN A PURELY RESIDENCE DISTRICT OF COLUMBUS, OHIO. POPULATION OF DISTRICT, 46 000. THE RECORDED PER CAPITA CONSUMPTION AT NIGHT EQUALS 1.6 GALLONS PER HOUR.

then set at the point of greatest velocity and remain there throughout the test.

The greater the velocity in the main, the greater the force with which the water impinges against the up-stream orifice, and it is the function of the metallic tubes, the rubber connections and the glass U-tube to communicate this pressure to the surface of mercury, or other liquid heavier than water, which will thus be depressed in one arm of the U-tube in accordance with this varying pressure. In order to make a permanent record of the movement of this liquid, the photo-recorder photographs the liquid upon a drum, which revolves steadily, thus showing a line on a sheet of paper which can be interpreted into gallons for any minute or hour of the day or night.

The pitometer, when thus used with a photo-recorder, registers automatically all the variations in velocity which take place in a water main. It is the only meter which can be used at will on all sizes of mains. It is portable and may be readily attached to any water main by means of a 1-inch corporation cock. A 1-inch reamer should be run entirely through the corporation and the key before placing it in the main. The location should be in a straight run of pipe, at least 50 feet, if possible, from all disturbing valves, bends, tees, etc. A less distance may be safe if the velocity is below 3 feet per second.

The uses of the pitometer may be classed under three heads, viz., engine tests, district surveys, and street inspections.

Engine Tests. The first work done is usually that of making a test of the pumping engines, or, in case of gravity works, of the reservoir flow. This indicates the deduction which must be made from station logs for slip of pumps or defective formulæ.

This test alone is often found to be one of great significance. Frequent slip-tests are of great utility, and if all works were equipped, it would enable the engineer in charge to make these himself at regular intervals.

District Surveys. The next step is usually that of dividing the area of the entire city into large districts. The flow of water into each of these districts is ascertained by the photo-recorder on a continuous run of several days and nights, including, if possible, a Sunday. From these records, which show the use for every hour, a comparison is made with the actual requirements of the district as shown by its total metered use and a reasonable allowance for its resident population, and in this way a valuable result is reached. It often happens in such cases that a large area is shown to use but a normal quantity, considering its population, and that the night flow is not greater than it should reasonably be. This fact, once established, makes further work in that district unnecessary. On the other hand, the record may reveal an abnormal flow into a district and an excessive night consumption. This indicates a section which should be subdivided and carefully investigated. Large losses through broken mains and services, and important uses that have not been fully metered and charged for, are readily determined by such a test.

Street Inspections. Taking now the districts which are evidently consuming an excess of water, especially at dead of night, the next step is that of taking records upon short lines of mains by shutting off in their order all the services supplied on the line. This process at once indicates a place where defective service pipes or imperfect fixtures are leaking. After all known services have been shut off there may still remain a flow that indicates loss from imperfect joints, a break in the main, or some unsuspected and unmetered consumer. In old works a frequent cause of leakage is found in decayed service pipes. Forgotten and disused services and mains are fruitful sources of loss. Fire-protection mains are peculiarly subject to losses through unmetered connections, which, for aught any one seems to know, have made themselves. This street inspection brings all such misfortunes to light, and its value can only be adequately understood when the cost of the water which flows away in a constant stream for a year, and year after year, is capitalized.

By using the pitometer street connection, records can be repeated at any given point, thus revealing the changes which take place from one season to another. This adds greatly to the ease with which the use of water throughout the system can be made a matter of certainty to the manager. By locating these street connections on fire-protection mains, inspections can be made from time to time which will prevent an unauthorized use of water through surreptitious connections. As this method of inspection leaves the main unobstructed at all times, its use is not objectionable from the fire underwriters' standpoint. If one of these street connections to each mile of main is judiciously set, it will be practicable to reach every block of a pipe system so as to determine positively whether any given water gate is shut or open, and also to locate any considerable loss of water through defective mains or services, or to locate the theft of water.

By using the pitometer in a thorough and systematic way in connection with careful inspections of fixtures, any city can know where the water of its system is used and can find every source of loss. It affords a very economical and practical way of measuring the water flowing through any pipe in any street. Its cost and its ease of handling are such that even the smallest waterworks plant can afford to use it. It is peculiarly fitted for use by large cities, where every mile of the pipe system can be inspected without interference with the supply of water.

In 1881 and later, a total of 83 Deacon meters were placed on the distribution system of the Boston Water Works in the study of waste. The average cost of their installation complete was about $600 each, making the total cost of installation in the neighborhood of $50 000. It is interesting to note that 500 pitometer street connections could be placed, one to each 3 miles of the 1 500 miles of piping of 4 inches and over supplied by the Metropolitan Water Works in 1905, and 100 complete pitometers with photo-recording apparatus installed, for the same sum of $50 000. By a careful study of the successive points of distribution of the pitometers, this equipment would enable the Board to learn the exact condition, flow, waste, leaks, breaks, etc., at every point in its large distribution system, and such data could be repeated at different periods as often as desired.

The writer installed and directed the operation of a complete pitometer, with photo-recording apparatus, at Athol, Mass., during the fall of 1905, for the purpose of determining the gravity flow through two mechanical filters. During the latter period of its operation, excavations were being made for the permanent installation of a Venturi meter at the same point. The flow by pitometer gagings was testified to at the hearings before a special commission, before any records had been taken from the Venturi, but when the Venturi records were entered in the later course of the testimony, they were found to agree very closely with the pitometer — as should always be the case when both are installed properly and operated intelligently. The pitometer was used successfully in the famous New York waste investigations of 1902 and 1903, and is in use to-day at Chicago, Philadelphia, Pittsburgh, Havana, Washington, Spokane, Minneapolis, Rochester, Syracuse, Cleveland, Watertown, N. Y., Bridgeport, New London, and other smaller cities and towns.

In preparing the above information to cover the limited time assigned to this paper, I have extracted freely from the text of the literature published by The Pitometer Company.

DISCUSSION.

MR. C. M. SAVILLE (by letter).* I think we are greatly indebted to Mr. Blake for his interesting exposition of the pitometer and its uses in connection with water-waste investigations, especially in cases where a hurried reconnoissance is to be made over a large system.

Regarding the suggestion for installing them on the Metropolitan Water Works, I would state that this system is now equipped with 55 Venturi meters, controlling all of the connections with the 18 separate cities and towns supplied from these works. From these meters an autographic record of the flow during *any* period is available and is filed for future reference. This record requires no expert knowledge of photography or manipulation in development, and the chart can be adjusted and taken off by a laborer of ordinary intelligence.

Besides the autographic record, which gives the rate of flow at any time, the Venturi register also shows on a dial, similar to that on the ordinary house meter, the total quantity in gallons actually passed. This is a great advantage over a chart record giving only rates of flow, as it requires no calculation to reduce it to the quantity actually consumed. The chart records have furnished very interesting and valuable information regarding the use of water for fires, blowing off and flushing water pipes and sewers, and the results on small systems of the sudden opening of connections for supplying street-watering carts and locomotive tanks. Besides the above, immediate information is given of gates carelessly opened between high and low service systems, and of breaks in mains and services from which water is running away unnoticed into drains and brooks.

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* Division Engineer, Metropolitan Water Works, Boston, Mass.

On the Metropolitan system these meters have been used many times to investigate waste, the method being to feed the system under inspection through the meter, noting the time of shutting section gates, cutting off certain portions of the district, and later reading the rates of flow on the meter charts at the time mentioned, the rate of decrease, or quantity used by the cut-out section, is readily obtained.

One step further in this method of waste detection would be to tap ordinary connections on either side of a section gate and lead, say, 2-inch connections into a permanent chamber. Here, by means of flanged connections, a small Venturi meter, say, 2-inch, could be inserted at any time. By closing the main gate between the connections the flow to the district under investigation could be by-passed through the small Venturi and by means of adjustable throat pieces any rate of flow per minute from 1.74 gallons or 0.23 cubic feet to 90 gallons or 12.1 cubic feet could be automatically recorded by a manometer, while street-by-street and house-to-house inspection by closing street gates and curb cocks is being done by the water works department. The great advantages of this method are:

1. Its low cost for installation, the entire first cost (and consequent ownership) being a comparatively small amount.
2. Its portability, one outfit of meter and manometer being readily transported and used in as many testing chambers as is required on the system.
3. Its autographic record, requiring no photographic manipulation, and being ready for inspection at any time without development.
4. No survey of the pipe and determination of a proper coefficient being necessary.
5. Its simplicity of operation, lending itself readily to operation by local departments.

MR. BLAKE (*by letter*). Mr. Saville's instructive discussion has been read with much interest. It was not intended to suggest that pitometers should now be installed on the Metropolitan system, but to show what might be accomplished by their use with an investment equal to that made with Deacon meters in 1881 and later. The comparison showed the great advantages of the pitometer in point of information obtainable for a given investment.

In regard to the expert knowledge of photography which Mr. Saville thinks is required, the writer would have endeavored to make this matter, as well as several other details, clearer had time permitted. The sensitized Velox paper can be purchased at any photographic supply store, cut into the exact size desired. It must be placed on the drum in a dark room or corner, and protected from the light until in place on the drum above the clockwork. When the record is completed, which may cover twelve, twenty-four, or forty-eight hours, the Velox paper is removed, and rolled in a small tin case. Tubes of developer and acid hypo for fixing solution can be bought cheaply at almost any stationery store. Fresh water is all that is required in addition, and the simple directions show the process plainly. Photography has become so common with even young boys and girls that it can hardly be said to require expert knowledge as demanded in the development of pitometer diagrams. A laborer of ordinary intelligence can put on and remove the Velox sheets, and, if desired, they can be collected once a day and developed at the office, where, with scarcely an exception, some assistant is found well versed in photography.

In regard to the Venturi dial, referred to by Mr. Saville, which shows at a glance the gallons passing at any moment, a pitometer scale is quickly made from the tables to suit any traverse coefficient and any size of pipe, and this scale, with its zero placed at the zero line of the liquid in the U-tube, enables the observer to note the exact number of gallons passing at any moment. Furthermore, notches in the slit through which the light passes on its way to the paper are so located that they produce horizontal rulings upon the record corresponding to the calibrated deflections, and after being developed, the discharge in gallons for the given traverse coefficient and pipe size is readily entered for each line of the record, making the record self-reading without calculation or scaling, except for intermediate points.

In the investigation of waste by the pitometer, any main can be tapped anywhere, except at or very near bends, branches, etc., without by-passing the entire supply or any part of it through a neck or other reduced section, and, of course, complete inspections can be made by shutting section gates, curb cocks, etc. Also changes in the rate of flow, due to use of water for fires, blowing off and flushing water pipes and sewers, the sudden opening or closing of gates, breaks in mains and services, etc., are faithfully recorded on the photometric diagram, not at ten-minute intervals, but continuously.

Mr. Saville suggests the use of a 2-inch Venturi meter with adjustable throat pieces in waste detection. He states that to do this would require a tap on each side of a section gate, 2-inch connections, and a permanent chamber.

Compare with this a single 1-inch corporation cock tapped into the main, a simple and inexpensive pitometer street connection placed in position, and the whole surrounded by a piece of 6-inch or 8-inch pipe running up to the surface and having an ordinary cap such as is used for curb cocks. There is no by-passing, no by-pass valves, no permanent chamber large enough for a man to work in. The comparison seems to show that for the particular field of waste detection the pitometer is preëminently fitted above all other types of meter, and is therefore destined to have a very wide use in the future, in view of the fact that every year cities and towns are made to realize that consumption must be minimized and unnecessary waste stopped. The pitometer reveals in part the actual interior condition of the pipe and measures the flow as it actually takes place in the pipe day by day.

The writer has been informed that the cost of installation of the 55 Venturi meters on the Metropolitan system was in the neighborhood of $90 000. The cost of an equal number of complete pitometers would probably not exceed $20 000. Making the same comparison as used in reference to the Deacon meters, for an equal investment of $90 000, 1 500 pitometer street connections could be placed, one on each mile of the 1 500 miles of piping of 4 inches and over in diameter, supplied by the Metropolitan Water Works in 1905, and 150 complete pitometers installed, or one to each ten miles of piping. Thus continuous records could be taken simultaneously at nearly three times as many points as is possible with the Venturi meters now in use, and then the pitometers could be moved to other 150 points, and so on, until the day and night flow on each mile of the system had been recorded. The great increase in information thus available is obvious; and although it doubtless would not be desirable to go into the matter so minutely on the Metropolitan system, the above figures are intended to show what might be accomplished by the use of pitometers with an investment equal to that made in the case of the 55 Venturi meters.

MR. GEORGE W. BATCHELDER.* We used the pitometer in the fall of 1903 with most satisfatory results. I do not remember having any difficulty with it, and do not think it requires any expert knowledge to operate it.

We found some very startling results on some of our fire pipes, which results were afterwards practically verified by the readings of meters placed on the pipes.

The instrument appeals to us as practical and easy of operation, so much so that we shall undoubtedly order one very shortly.

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* Water Commissioner, Worcester, Mass.

WATER SUPPLY, TYPHOID FEVER, DIARRHEAL DISEASES, AND INFANT MORTALITY AT BURLINGTON, VT., 1879 TO 1905, INCLUSIVE.

BY M. N. BAKER, PRESIDENT OF THE BOARD OF HEALTH, MONTCLAIR, N. J., AND ASSOCIATE EDITOR OF "ENGINEERING NEWS."

[*Read March 14, 1906.*]

The water supply of Burlington, Vt., affords an exceptional opportunity to study the relations between water supply and disease, and to extend such studies so that in addition to typhoid fever they will include both diarrheal diseases and infant mortality. This opportunity is due to the fact that Burlington draws its water supply and discharges its sewage alike into Lake Champlain, without purification in either case, and to the further fact that its vital statistics, while not wholly satisfactory, have for a long period of years been superior to those of most cities. The study is rendered doubly interesting and significant because two increases in the distance between the water intake and the main sewage outlet, making a final distance apart of some three miles, as compared with a half mile originally, appear to have failed to protect the water supply from the constantly increasing discharge of sewage into the lake, which latter has been augmented of late by the sewage of other localities than Burlington.

My first acquaintance with the water supply at Burlington was in the fall of 1882, when upon entering the University of Vermont I received the warning customarily given to students, to drink sparingly of the lake water until accustomed to it, lest it should give rise to diarrheal trouble. During and subsequent to my course at the university, I followed with interest the local contentions over the relation between the water supply of the city and typhoid fever, diarrhea, and dysentery, which many believed were unduly prevalent in Burlington.

In common with others who gave attention to the subject, I thought that the 2½-mile extension to the water-works intake made in 1894, which had long been advocated, would secure to Burlington the purity of its water supply for many years to come. At the annual convention of the New England Water Works Association held at Burlington in September, 1895, I listened with great interest to the paper on the history of the Burlington water works and the account of the construction of the intake extension, by my former classmate at the University of Vermont, Mr. F. H. Crandall, then and until recently superintendent of the Burlington water works. At the same convention I heard with much pleasure and profit the notable paper by Prof. William T. Sedgwick, now president of this Association, " On the Sanitary Condition, Past and Present, of the Water Supply of Burlington, Vt." (See JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, Vol. X, pp. 150-183, March, 1896, for both these papers.) After the completion of the intake and the presentation of the two papers just named, with their evidently conclusive testimony on the existing and probable future water supply of Burlington, the controversial aspects of the subject passed out of my mind until the publication in 1905 of Mr. M. O. Leighton's " Preliminary Report on the Pollution of Lake Champlain " (Water Supply and Irrigation Paper No. 21, United States Geological Survey). In this report Mr. Leighton considered at some length the history and character of the water supply of Burlington, and included many analyses of samples of water collected from the lake. On reading this report I was surprised to learn that Mr. Leighton's studies, combined with analyses made by the Vermont State Laboratory of Hygiene, at Burlington, indicated that the water supply of that city was again in a dangerous condition. About this time the Vermont State Board of Health issued an order instructing Burlington to improve the character of its water supply. The city authorities appointed a special committee to investigate and report on the subject. The membership of this committee included Dr. John B. Wheeler, chairman, and Dr. F. E. Clark, secretary, both former health officers of the city, and Mr. F. O. Sinclair, M. Am. Soc. C. E., then recently appointed superintendent of water works. In June, 1905, I was requested by the committee to report on the best means of improving the supply. My report was submitted in the following August. Its conclusions, in brief, were that the statistics of typhoid fever and diarrheal diseases, together with the analyses of the water supply, indicated that some change in the water supply was necessary, and that in view of the abundant supply afforded by the lake and the fact that the works were designed to draw thereupon, it was advisable to continue the supply from that source and to purify it by means of slow sand filtration. Subsequently the special committee embodied my report in one made by it to the city council. In general, my recommendations were indorsed, with the exception that it was not considered necessary to cover the storage reservoirs on the hill, and that the filter plant should be located at these reservoirs instead of at the lake, as suggested by me. By locating the filters on the hill, the necessity of low-lift pumps would be obviated, and by constructing a new force main from the pumping station to the filters, it would be possible to supply a considerable amount of unfiltered water in the heart of the business district for both fire protection and elevator service. The existing force main, it may be explained, serves as a distributer to branch mains along its course; that is, the system is by pumping through the distributing system to the reservoirs, the latter serving to make up any deficiency and to supply the city at any time when the pumps are closed down. Reference to other features of these reports will be made later on.

In view of the detailed information regarding the Burlington water supply already available in the papers by Professor Sedgwick and Mr. Crandall, as printed in the JOURNAL, and in Mr. Leighton's report, it seems unnecessary to go over the subject in detail. A few facts, however, may be drawn from each one of the papers named. These facts, combined with other information, having been given, I shall address myself to the presentation and discussion of those portions of the vital statistics of Burlington which bear particularly on the subject in hand.

On October 1, 1866, the city of Burlington took possession by purchase of the property of the Burlington Aqueduct Company. This company was then supplying water for domestic purposes only, by gravity, from springs located near a 75 000-gallon underground reservoir. On taking possession of the works, the city installed a pump having a capacity of 63 000 gallons per day, and began pumping the water from the lake to augment the supply of 5 000 to 15 000 gallons daily, delivered through some 200 service connections. On December 25, 1867, the city began the use of a new water-works system which it had built for drawing water from the lake. The intake was only a short distance from the pumping station, which was located on the lake front. This intake continued in use until the completion, in 1894, of the 2¼-mile intake extension already mentioned. One or more sewers seem to have been in use prior to 1867, but there appears to have been no sewerage system until 1875. Up to 1885 the main outlet sewer discharged at the dock line about a half mile south of the water intake. In that year an intercepting sewer appears to have been constructed to convey the sewage to a point farther south, the new outlet being about three fourths of a mile from the water-works intake. Storm overflows, it appears, have continued in use since this extension. The water intake extension of 1894 separated the water intake and outlet sewer by about three miles, but at the same time the outlet sewer, which had previously discharged into quiet water, serving as a settling basin, was extended to the dock line, and since then it has discharged into the open lake. The effect of the basin named was to remove, presumably, a considerable part of the dangerous polluting matter from the sewage before the latter reached the main lake. With the extension of the outlet to the dock line the full volume of sewage was subject to the lake currents, as exercised within the line of the breakwater, which parallels the water front for about a mile. The normal lake current is, of course, to the north, but this current is gentle, and within the bay and breakwater it is not only less pronounced than without, but it is also liable to reversal, at least at the surface, by adverse winds.

The new water intake was composed of 24-inch cast-iron pipe, laid in 75-foot sections, with Falcon ball joints between sections. The 75-foot sections were joined by leading in the usual way, the joints being of the bell-and-spigot type. This jointing was done on shore, and each 75-foot section was tested under hydraulic pressure. The sections were then moved out by scows, sunk, and the ball-and-socket joints, which, of course, had been applied beforehand, were connected under water by a diver. The Falcon joints are described by Mr. Crandall as follows:

> "This joint is made of a ball cast of such diameter, larger than the pipe on which it is to be used, as to admit the desired deflection to be obtained without obstructing the waterway, and a flanged spherical ring of about three-eighths inch greater radius than the ball and of such width that the ball cannot pass through it. These two parts are leaded together and attached to one end and a flanged bell, planed so as to make a tight thimble for the ring which is attached to the other end of a section to be laid.
>
> "The flanged joint is made by a diver with the aid of a thin rubber packing, and after it has been for a short time in our lake water the oxidation which takes place on the planed surface of the ring and thimble makes it entirely watertight. In a case like that of our intake, where there is no current of constant and high velocity to keep open and increase the size of leaks induced by changes of temperature or settlement, it may safely be expected that all small holes will be closed by oxidation."

Mr. Crandall stated in his paper that the bottom of the lake, on which the pipe rests,

> "is nearly level, but there are two summits in the distance, and on those summits were placed brass ferrules with two one-eighth-inch holes bored in each ferrule. Before these holes were opened, the water was let on at a pressure of about 20 pounds, and we noted the amount of leakage, and the same was done afterwards, showing the leakage occasioned by the holes. This was done each time that air vents were placed, and when the test was finally made, the pressure which they were subjected to was from 12 to 15 pounds, and the leakage, aside from that through the air vents, was about 100 gallons per hour in the entire length of about 3 miles."

Attention is called to these descriptions of the methods employed in making and testing the lead joints on shore, connecting the sections under water, and testing the intake conduit after it was laid. The question naturally arises whether all the joints made under water rusted to tightness, as Mr. Crandall expected would be the case.

The provision of a gate at each extremity of the intake conduit, that is to say, at the pump well and at the upturned outer end of the intake, made it possible to retest the whole intake at any time after it was put in use. No reference to such tests has been found by me in the annual reports of the Water Department; and although the first recommendation of my report, dated August 30, 1905, was that such tests be made, none had been undertaken up to March 1, 1906.

It should be noted that the intake conduit was laid in water ranging from some 14 to 50 feet in depth, and terminated in water some 30 feet deep, but with a strainer capped, upturned end, the upper portion of the perforated cap being 14 feet below ordinary low water in the lake. The successive depths at which the intake was laid from the pumping station outward, at approximately equal intervals, were as follows: 12 feet (near the shore), 24, 38, 46, 48, 46, 46, 28, 45, 50, 44, 29, 31 (and 14 at the strainer, at stated above).

Professor Sedgwick's paper contains a number of very interesting extracts from the reports of successive health officers, beginning as early as 1870, calling attention almost without exception to the desirability of extending the old intake at once. The two exceptions were to the effect that the allegations against the character of the city water supply were apparently unfounded. In the year 1870, Professor Sedgwick states, there were 5 deaths in Burlington from dysentery and 3 from diarrhea, and in 1871 there were 10 deaths from dysentery, according to the city reports. These figures certainly emphasize the need, even as early as 1870, for the extension of the intake, which was deferred, as already indicated, until 1894. Professor Sedgwick included in his paper the substance of a report made by him to the city of Burlington in 1892. In that report he reviewed briefly the typhoid statistics of the city for some years previous. The typhoid mortality, together with the deaths from diarrhea and dysentery, he did not consider alarming; nevertheless, the body of the statistical evidence available, combined with the opinions of successive health officers and practicing physicians, and the known fact that sewage was discharged into the lake so near the intake, all pointed, he concluded, to the need of an improved water supply, which it then appeared could best be secured by extending the intake. Such an extension seemed all the more desirable at that time because Mr. F. P. Stearns, M. Am. Soc. C. E., had just been called in to advise on the abolition of the nuisance caused at low water by the discharge of sewage into the basin at the mouth of the outlet sewer. Quite recently the lake had been unusually low and the exposure of the sludge-covered mud flats in the basin had resulted in an almost intolerable stench. Mr. Stearns advised that the outlet sewer be extended across the basin to the lake front. This, as has already been mentioned, was completed the same year as was the extension of the water intake.

Between the date of his report and of his paper read in 1895, Professor Sedgwick made numerous bacterial analyses of water from the Burlington supply, and took pains to secure the opinion of some of the physicians of Burlington as to the benefits derived from the extension of the water-works intake. The concluding paragraphs of Professor Sedgwick's paper of 1895 are well worthy of quotation here:

"In view of all the evidence at hand — statistical, bacteriological, chemical, and medical — I think we may safely conclude that the sanitary condition of the water supply of Burlington is now most excellent. If, however, in the future, Burlington grows extensively and becomes a much larger city, it will probably become necessary here, as in most large cities, to face once more the question of a pure water supply. Special pains must also be taken to see to it that the intake pipe is kept intact and free from leakage. The unfortunate experiences of Toronto and of Buffalo with broken intake pipes afford ample warnings in this direction.

"This is the first case within my own experience, now somewhat extensive, in which epidemic diarrhea in a mild form has prevailed in a community for many years, having its etiology in the consumption of impure water, as has been proved by its apparent total disappearance on a change in the source of supply. The importance of the case in the history of water-borne diseases is manifest. It was complicated by the fact that typhoid fever, which is usually taken as a measure of the sanitary condition of a community, was here ordinarily by no means excessive, and that its occasional prevalence might easily have been due to some other cause than polluted water. The fact seems to be, however, that it was in truth really due to impure water, inasmuch as since the extension of the intake pipe in 1894, typhoid fever has practically disappeared.

"It would seem fair to conclude, from the moderate occurrence of typhoid fever, while diarrhea abounded, that germs of the latter disease, more hardy than those of the former, were frequently able to survive a journey from the sewer outfall to the water intake, while those of typhoid fever, if present, usually perished. In future, sanitarians will not be able by the test of typhoid fever alone to show that a water supply is above suspicion. A mild form of diarrhea caused by polluted water may apparently prevail even in the absence of any constant or considerable excess of typhoid fever."

At the conclusion of the first of the paragraphs just quoted, it will be noted that Professor Sedgwick suggested two possible future contingencies which might demand renewed efforts to secure or maintain a pure water supply: (1) A large increase in the population of Burlington, which has scarcely taken place yet, since the population now appears to be only some 25 per cent. more than it was then; and (2) leaks in the long intake pipe, on which possibility there seems to be no specific information available up to the present time. But in some respects even more impressive than these two suggestions are the remarks in the last paragraph of the quotation, on the relation between a polluted water supply and an excessive amount of diarrhea. This summary of a most significant feature of the sanitary history of the Burlington water supply, and particularly the last two sentences of the paragraph, mark a new epoch, as I believe, in the study of the relations between water supply and disease. The impression made upon me by these remarks, taken in connection with my early knowledge of the effect of the Burlington water supply upon new students at the University of Vermont, and my long-time conviction that sewage pollution did cause other intestinal disturbances than typhoid fever, determined me, on taking up the investigation of the Burlington water supply last year, to attempt a more detailed study of both the typhoid and diarrheal mortality of Burlington than had ever been made before. This determination was strengthened after some study of the Burlington typhoid had confirmed the opinion, by no means held by me alone, that much of the disease had been concealed, particularly in earlier years, by reporting deaths that were actually from typhoid fever as some one of the now well-recognized class of diarrheal diseases.

Never was the need of combining the study of vital statistics with that of chemical and bacterial analysis of a public water supply better illustrated than by this Burlington case. The futility of water analyses alone is well put by Mr. Leighton in his paper on the "Pollution of Lake Champlain." After reviewing the sanitary history of the Burlington water supply, Mr. Leighton says:

> "One of the most striking features in connection with Burlington pollution brought out by the report of Professor Sedgwick is the apparently enormous power possessed by the lake to assimilate large quantities of contaminating matter and to conceal almost every chemical as well as biological evidence of the presence of pollution."

Mr. Leighton also raised the question whether, in the twelve years since Professor Sedgwick's report, the lake, or rather Burlington Bay, had received so much pollution that it had lost a part of its power of assimilating impurities. He then presented a number of series of analyses of samples of water, collected in the latter part of 1904, the analyses and text being accompanied with charts showing the sampling points. The object of these analyses was to show the range and strength of sewage pollution, both that due to the sewers of Burlington, discharging some three miles to the south of the water intake, and that due to the sewage of Fort Ethan Allen and the village of Winooski, discharged by way of the Winooski River at a point in the lake about three and one-half miles to the north of the intake, Winooski being nearly ten miles, by the river, from the river mouth, and the fort some miles above Winooski. (See discussion of the Winooski River influence, further on.) Much of Mr. Leighton's analytical work was admittedly tentative, some of the results were conflicting, and most of the samples from given points were of a single date only, but the analyses as a whole were instructive and indicated sewage pollution over a large area, including most of the area traversed by the intake conduit and also the area between the intake mouth and the mouth of the Winooski River. Such evidence as was secured rested chiefly on the bacterial rather than the chemical analyses. Most of the counts of total bacteria were not high, all things considered, but the colon bacillus was indicated by many of the samples. Mr. Leighton points out, however, that the coli tests, as made for him at the Vermont State Laboratory of Hygiene, were presumptive, instead of direct, but nevertheless he considered that such of these as gave positive results were undoubted evidence of intestinal bacteria. He held, in conclusion, that the Burlington water supply was undoubtedly polluted by sewage, but that in view of the illusive character of the sewage contamination, so far as analytical determinations are concerned, the record of intestinal diseases in Burlington was the best means of showing " the unfavorable effects of Burlington sewage " on the water supply of the city.

In none of the published studies of the Burlington water supply, and in none of the annual reports of the various health officers of Burlington, do there appear (with one exception) detailed typhoid statistics for a long series of years; and nowhere have there been published detailed statistics of diarrheal mortality. In Professor Sedgwick's paper, already mentioned, the total mortality, typhoid mortality, and percentage of the latter to the former, were given for the years 1870 to 1895, inclusive, and some figures were also given of the typhoid rate per 100 000 for selected years and for groups of years.

Although my first negotiations with the special water supply committee at Burlington, in June, 1905, assumed that both the pollution of the water supply and the necessity for a change of some kind were proven, yet it was finally deemed advisable to show beyond all question, in connection with recommendations for improving the supply, why an improvement, and that immediately, was imperative. I therefore devoted practically all of my spare evenings, for a number of weeks in the summer of 1905 (largely as a labor of love), to an exhaustive study of the Burlington city reports and a compilation and analysis of such of the vital statistics of Burlington as I thought bore upon the subject in hand. I had in my possession the annual reports of the city from the fourth to the fortieth (1868–69 to 1904, inclusive), but inasmuch as the registration of vital statistics did not begin at Burlington until well into the year 1878, I started my figures with the calendar year 1879. Prior to 1878 and well into that year, the vital statistics of Burlington were based upon a canvass of the city made in January of each year. As may be seen from Professor Sedgwick's paper (page 175), no deaths from typhoid were reported in Burlington for the three years 1873 to 1875, inclusive. In view of the fact that this statistical work of mine, as already stated, was largely a labor of love, and that my report to the special water commission has recently been published minus all the statistical tables (Burlington City Report for 1905), perhaps I need not apologize for presenting the tables complete herewith, with the corresponding figures for the full year 1905 added thereto. I shall also take the liberty of repeating, without quotation marks, considerable portions of my comments on the tables, as made in the appendix to my report, but with some alterations in form and with some additional reflections.

For a number of years, beginning with 1879, the vital statistics of Burlington probably surpassed in completeness and classification those of most cities of its size. There is reason for believing that they are still more than usually complete and well summarized, but it seems a pity that Burlington has not yet adopted the United States census classification of the causes of deaths and thus put its mortality records on a comparative basis with those of other cities. However, most of the essential facts appear to have been given for some years past, rendering a reclassification no serious matter. The footnotes to some of the accompanying tables will show the new classifications and combinations made in connection with deaths from typhoid fever and from diarrheal diseases.

Table No. 1 shows by years, from 1879 to 1905, inclusive, or for twenty-seven years, the midyear populations, total deaths, and deaths per 1 000 population, and also for typhoid fever, diarrheal diseases, and children under five years of age, the number of deaths and the death rates per 100 000 population and the percentage which the deaths from each of these diseases bears to the deaths from all causes. For typhoid fever alone an attempt has been made to include the yearly number of cases, but it was not until 1898 that the cases began to be reported with anything like apparent completeness, the deaths actually equaling or exceeding the cases in the earlier years and the cases not being reported at all in years as recent as 1889 and 1890. As may be seen, this table shows great fluctuations in all mortality particulars except the death-rate from all causes, which has been fairly constant, and that at a high rate for a city under such favorable natural conditions as are enjoyed at Burlington. Particular attention is called to the fact that although the typhoid deaths for the year 1905 are low, only 15 per 100 000 population, yet the number of reported cases (32) is high, and so are the total deaths and the deaths from diarrheal diseases and of children under five years of age.

Before proceeding further, I wish to explain why I have included deaths from diarrheal diseases in my study and also deaths of children under five years of age. It has been usual, heretofore, to stop short with a consideration of typhoid fever as an index of water pollution and a measure of the effect of such pollution on the public health. The idea has often been expressed, however, that public water supplies unquestionably affect the total death-rate otherwise than through typhoid fever. How to measure that further influence has never yet been determined, so far as I know, but it has been suggested again and again that the large class of diseases known as diarrheal have their many fatalities raised or lowered by the sanitary quality of the water supply.

Unfortunately, mere cases of diarrhea are not reported at Burlington, or, so far as I know, in any other American city. In fact, unless serious, most of them do not come to the attention of a physician. Deaths from diarrhea have not figured high at Burlington, at least not as indicated by the published vital statistics. This may be due to difficult, even if not to faulty, classification and to variations in the classification of reporting physicians from year to year. To have some broader and more stable basis of comparison than is afforded by diarrhea, or even diarrhea and dysentery together, I have included in my Table No. 1 the whole class of diarrheal diseases, as used by the United States Census Bureau. The details on which depend the total for diarrheal diseases shown in Table No. 1 are given in Table No. 2. I have been compelled to add two columns to the list of headings taken from the census, namely, gastro-enteritis and ulceration of the bowels. If I may venture an opinion on such a subject I would suggest that some of the entries under these two heads, under more recent diagnosis, would have swelled the typhoid fever totals, as given in Table No. 1, for the corresponding years. The same is doubtless true of some of the other entries in Table No. 2. In fact, I think this table as a whole is a strong argument for an entire change of base in the study of polluted water supplies and the public health, particularly in the case of the older records. But to hold more specifically to the case of Burlington, I think no impartial competent judge who is or could become familiar with the past disputes at Burlington over the relation between the public water supply and typhoid fever could study the detailed figures of typhoid fever and of diarrheal diseases brought together in this report without being convinced that Burlington has had far more typhoid fever than was ever reported as such, and that there was far more relation between the water supply and diarrheal diseases than has generally been supposed.

The cholera infantum column (Table No. 2) may be consulted with possible profit in connection with both the total deaths from diarrhea and the infant mortality (the latter given in Table No. 1). Some may be inclined to exclude cholera infantum from diarrheal diseases as related to public water supplies, and others to connect many of the cases with impure water. The figures will be interesting to either school of opinion.

The high infant (persons under five) mortality, whether or not attributed in part to the water supply, certainly demands attention, particularly as it shows comparatively little improvement of late.

If it be assumed, as I have for some years past, that a persistent typhoid death-rate of 20 or more per 100 000 population is a reflection on a public water supply, it will be seen from Table No. 1 that the Burlington supply has been subject to condemnation through the greater part of the twenty-seven years covered by the table, with no allowances whatever for the deficiencies in the statistics. The rate has ranged from 6 to 79 per 100 000 and in sixteen of the twenty-seven years has exceeded 27 per 100 000.

In his report to the city of Burlington, made in 1892, Professor Sedgwick referred to an average typhoid rate of 35.7 per 100 000 for a term of years as not high, compared with other cities having water supplies of good reputation. For that date, and coming at about the time of the notable studies of typhoid fever and water supply at Chicago, Philadelphia, and elsewhere, made by Professor Sedgwick and Mr. Allen Hazen, perhaps an average typhoid death-rate of 35 per 100 000 might not be considered excessive, but I think few persons to-day will fail to agree that so high a rate is a cause for deep concern, particularly if it is suspected that all typhoid deaths are not reported as such, and if it is found that diarrheal and infantile mortalities are high. In no less than 8 of the 27 years between 1879 and 1905, inclusive, was the typhoid death-rate at Burlington above 35 per 100 000, while for these eight years the combined mortality from typhoid fever, diarrhea, and infantile diseases ranged from 46 to 68 per cent. of the deaths from all causes. For convenience of comparison I have brought together in Table 2–A the deaths per 100 000 from all causes and from the three causes named, for the eight years in question; and to emphasize the bad general showing of 1905, notwithstanding its low typhoid mortality of 15 per 100 000, I have added the corresponding figures for that year.

Having examined the yearly figures and their vagaries in some detail, it may lessen the resulting confusion if we smooth out the extremes by considering averages for larger periods. In order to get equal periods for comparison; and also to put by itself the year in which was made the 2½-mile extension of the water intake, the averages have been cast in the three five-year groups preceding and two similar groups following the year 1894. For our purposes the most significant columns in Table No. 3 are those relating to typhoid fever. The deaths per 100 000 from this disease rose from 27 for the five years ending with 1883 to 42 for the next five years and 44 for the years 1889–93, inclusive. The new intake was put in use some time in August, 1894, and for that calendar year the rate fell to 12. In 1895 (Table No. 1) it dropped to 6 per 100 000, but for the five years ending with 1899 it was 16. During the period 1900–4 the rate rose to an average of 25, or nearly equal to the rate for 1879–83. In 1905 it fell to 15, but, as already stated, the total number of typhoid cases and the other statistics in Table No. 1 are far from reassuring.

The diarrheal diseases, if we take both the deaths per 100 000 and the percentages of deaths from all causes into account, show an increase before and a decrease upon and after the intake extension. Deaths under five years increased in the second five-year period, dropped in the third period and fell still further in 1894; since 1894 they have risen and fallen, successively, standing for 1900–4 quite near the rate figures for 1889–93. For 1905 the mortality from diarrheal diseases was higher than it had been since 1897.

By way of comparison, it may be noted that for the registration cities of the United States in the year 1900, according to the Twelfth United States Census, the diarrheal diseases gave an average of 156.7 deaths per 100 000; the range was from 191.7 for Rhode Island to 117.6 for Michigan cities. The corresponding rural rates were 97.2 for all the registration states; 172 for Rhode Island and 65.6 for Vermont. At Burlington the diarrheal death-rate in 1900 was 182; in 1904, 168; and in 1905 it rose to 232.

So many other factors than water supply enter into both the diarrheal and the under-five-year rates, and particularly into the latter, that undue weight should not be given those rates, but on the whole there is reason for congratulation in their general continued downward tendency and also in the like progress of the general mortality or deaths from all causes. But these several declines make all the more striking the recent steady increase in the typhoid deaths per 100 000. Turning from the five-year periods back to the yearly figures, we find that the typhoid death-rate per 100 000 of 36 in 1904 and of 38 in 1900 have not been exceeded in any single year since the rates of 63 and 45 in 1893 and 1892, respectively.

It is only fair to the water supply to say that milk, oysters, and some other foods liable to sewage pollution may spread typhoid; and that the common house fly is now believed to be a means of infecting food, in sections where privies exist and are accessible to flies. It should also be noted that with populations no larger and typhoid deaths no more numerous than found in Burlington, a slight addition to or decrease in the number of deaths from typhoid makes large variations in yearly rates and in percentages of typhoid to total deaths. Contaminated milk from some dairy or a shipment to Burlington of contaminated oysters might not cause an epidemic of such magnitude as to lead to a discovery of the real cause of the trouble, but by adding five typhoid deaths to the list might greatly increase the typhoid death-rate for a given year. Another possible factor in the typhoid fluctuations may be patients from outside Burlington admitted to the Mary Fletcher Hospital. It may be noted here that the hospital sewage for some years was discharged into the Winooski River, but about 1892 it was diverted into the lake, thus possibly intensifying the danger of typhoid infection from the water supply. The mention of the hospital also suggests two other institutions which in times past, and I presume at the present time, add an element to the population which may have a marked effect on the returns of deaths from both diarrheal diseases and children under five years of age. I refer to the two children's homes in the city, which at times have added materially to the infant population by receiving children from other parts of Vermont, and therefore may explain, in part, the high infant and diarrheal disease mortality. It is not probable that milk and other food infection combined with the hospital and the institutions for children would fully account for the unsatisfactory typhoid and other vital statistics, though possibly they would lessen somewhat the reflections cast on the water supply.

Unfortunately, the annual reports of the various health officers of Burlington throw no light upon any of the questions raised in the last few paragraphs. They show no investigation whatever of individual cases of and deaths from typhoid fever for the purpose of tracing and removing the source of infection. They give evidence of much concern regarding the public water supply, but of no attempt to settle its actual or assumed connection with typhoid fever, further than through water analyses. I am the more surprised at this because of the evident care and thought given to some phases of health work in Burlington during the past thirty-five years.

The lack or apparent lack of all evidence of the class just named seems to force us back upon deductions already drawn from the data thus far presented, and upon some further details of the same general character, namely, the monthly distribution of deaths from typhoid fever and some digests of water analyses.

Table No. 4 shows the monthly distribution of typhoid deaths from 1879 to 1905, inclusive. The total typhoid deaths for each month during the entire period are also given, and have been rearranged from greatest to least in one of the footnotes to the table. The combined Februarys have 19 of the 120 deaths occurring during the twenty-seven years, and the combined January–March quarters have 44 of the 120 deaths. The lowest combined quarterly showing is 19 typhoid deaths for April–June. The indications are that the ice-covering of the lake is conducive to a high typhoid death-rate. Unfortunately, the returns of cases are too incomplete, particularly in the earlier years, to be of much value.

A study of the analyses made at the State Laboratory of Hygiene, and published in the yearly report of the Water Department, indicates that since 1899, when analyses were begun, the water has frequently been of a decidedly suspicious character. Table No. 5 presents averages of some of the leading features of these analyses. The chemical figures for 1899 and 1900 are notably higher and the bacterial figures decidedly lower than those for later years, except that the total bacterial counts for 1905 averaged the lowest of those for any year shown in the table. Altogether the analyses show variations not easily explained, particularly when taken in conjunction with the vital statistics. On the face of the figures the average analytical results have improved or remained about stationary, save for a slight increase in total bacteria up to and including 1904, a marked fall (to 172 per cubic centimeter) in 1905, and also a recent increase in the relative number of samples showing *B. coli communis*, or the organism common to sewage.

A much more extended series of *B. coli* determinations than those published in the annual reports was concluded at the State Laboratory of Hygiene in January, 1905. A summary of these daily examinations is given herewith, as Table No. 6. It will be seen that of 337 daily samples no less than 147, or 44 per cent., showed *B. coli* present; also that the percentages by months ranged from 60 in December and 57 in January to 25 in July. Judged by generally accepted standards, these daily coli tests afford the most direct and damaging of all the recent testimony against the water supply.

When the intake was extended it was supposed that danger from sewage contamination was removed for many years to come. To account for its so speedy recurrence is not easy, in view of all the circumstances thus far presented, unless one accepts either one or the other of two possibilities: increase in volume of sewage resulting in a wider range of sewage influence, or else leaks in the intake.

As to the volume of sewage now reaching the lake and the probability of its being carried to the mouth of the intake, the following is interesting, even though not conclusive, so far as actual effects are concerned: The sewer outfall is about three miles from the intake. Mr. Leighton's studies led him to conclude that the sewage influences are widely extended and sometimes reach the intake. He gave no little weight to the pollution of the lake at the intake by the sewage brought down in the Winooski River. Unquestionably this is a possible source of danger, but it appears to be far more remote than the danger from the sewage which Burlington discharges directly into the lake. This is evident on considering that from the intake to the mouth of the Winooski is 3½ miles; from the mouth of the river to the poor-farm, 25 000 feet, and to the falls of the Winooski 25 000 feet more. For these distances I am indebted to Mr. F. O. Sinclair, superintendent of water works at Burlington, who also informs me that a small amount of crude sewage is discharged into the river from the poor-farm buildings; that a small part of the population of Burlington is served by a sewer which discharges into the river below the falls; and that Winooski is well provided with sewers, all of which discharge at or near the Falls. Winooski had a population of 3 659 in 1900. Above Winooski, Fort Ethan Allen, I am informed, discharges the sewage of 1 000 or more men into the river, and above that there can be no large amount of sewage pollution until Montpelier is reached, and the direct pollution there, I should suppose, is not large.

According to Mr. Leighton's paper, the Winooski River has a total drainage area of 395 square miles. As nearly all the sewage reaches the river at and above Winooski, it will be seen that before reaching the intake it must pass nearly ten miles through a relatively large, sluggish, and tortuous stream, and then 3½ miles across the lake, or more than 13 miles in all. Sedimentation and other natural causes in the river and the same factors in the lake, generally acting in the latter case over a wide area and assisted by a still greater dilution, must reduce to a very low figure the usual number of sewage bacteria reaching the intake by way of the river. Among these it is probable, though not certain, that the typhoid bacillus would seldom be found, as water is far from being its natural habitat and it is less hardy in water than *B. coli* and other forms.

The poor-farm sewage stands much more chance than does any other conveyed by the river of reaching the intake in a dangerous condition, since it is so much nearer. Perhaps more serious still, though of this I have little information, is the rendering works on or near the lake shore opposite the intake. Dejecta from cases of typhoid fever at either the poor-farm or the rendering works might be cause for uneasiness if they were allowed to get into the river or lake without thorough disinfection. The populations involved at these points, however, are small.

Reverting now to the sewage of Burlington, as discharged directly into the lake, some idea of what this amounts to can be gained from Table No. 7, which shows by five-year intervals the lengths of all sewers within the city as compared with the mileage of streets and of water mains. It was not until 1895 that a third of the street mileage was provided with sewers, and at the close of 1905 only half of the street mileage had sewers. The water mains have always covered a much larger percentage of the street lengths than have the sewers. Since 1895 the sewer mileage has increased by half, and presumably a far larger percentage of the population is sewered than is indicated by the relation between sewer and street mileage. Lack of sewer connection records in early years makes a direct comparison of sewer and water connections impossible. All the indications are that the percentage of the total population connected with the sewers has increased much faster of late than the total population itself, and that this will be the rule for some years to come. This fact may have no little bearing upon the apparently more rapid increase of pollution of the lake by sewage than was expected when the intake was extended.

Obviously the Burlington records ought to show how many and just what houses are connected with the sewers. Such knowledge is essential to modern health-protective work. A more vital lack in the health-protective equipment of Burlington is the absence of a milk ordinance, combined with dairy inspections, dairy and milk dealer licenses, and other essentials to the full control of the sanitary condition of the milk supply of the city. A milk ordinance of June, 1901, aims to guard milk consumers against tuberculosis, the dissemination of which through milk is a mooted question, and against milk adulteration, which is largely a question of economics rather than sanitation, but leaves the people wholly unguarded against the spread of typhoid fever, scarlet fever, and diphtheria, and the aggravation if not the spread of infantile diarrheal diseases through dirty and germ-infected milk. To this negligence I attribute no small part of the excessive infant and diarrheal diseases mortality, and through these the high general death-rate as well, which latter is excessive for a city of the size, character, and natural advantages of Burlington. It is also probable that some of the typhoid fever has been due to a lack of complete sanitary supervision of the milk supply.

The foregoing paragraph completes the modified excerpts from my Burlington report. It would be highly interesting, and probably instructive, if time permitted, to extend this study in the following particulars: Typhoid records of Winooski village and of Fort Ethan Allen, and the extent of the Winooski sewerage system at various dates; out-of-town patients, total deaths, and typhoid deaths, by years, at the Mary Fletcher Hospital, and possibly the yearly number of inmates and the vital statistics of the two children's homes; and notably, as affecting the total and the infant mortality, the distribution of population of Burlington by age and nativity. It seems probable that the number of children in Burlington is unusually high in proportion to the population, owing to the presence of the two children's homes and the considerable number of French Canadians living in the city. But none or all of these further lines of investigation give promise of removing or to any great extent lessening the suspicion attaching to the water supply of the city. It is of the highest importance that it be determined at once whether the intake conduit is leaking, and if so whether the water thus admitted is worse than that taken in at the intake mouth. Such a determination involves tests for tightness, provided for by the gates placed at each end of the conduit when it was constructed, and also a fairly extensive series of analytical tests of water taken from points over the intake mouth and at selected points over the whole length of the intake conduit.

Finally, in the light of the statistical and other evidence presented by Professor Sedgwick, Mr. Leighton, the Vermont Laboratory of Hygiene, and myself, it seems that the principle laid down by Professor Sedgwick more than ten years ago, and already once quoted in this paper, is now established beyond all question, namely: "In future, sanitarians will not be able by the test of typhoid fever alone to show that a water supply is above suspicion." The additional test suggested or implied by Professor Sedgwick was the statistics of diarrhea. It does not seem to me, however, that these additional figures alone, in the present state of vital statistics, will be adequate. I do not make so bold as to claim that the whole group of diarrheal diseases, and the infant mortality as well, are essential to the study of the relations between polluted water and disease, but I think the evidence points that way to such an extent as to demand further and broader investigation.

TABLE No. 1. — POPULATION, TOTAL AND TYPHOID DEATHS, AND OTHER VITAL STATISTICS OF BURLINGTON, VT., 1879 TO 1905, INCLUSIVE.

	POPULATION.*	Total Deaths.	Deaths per 1 000.	TYPHOID FEVER.				DEATHS FROM DIARRHEAL DISEASES.			DEATHS UNDER 5 YEARS.		
				Cases.‡	Deaths.								
					Total	Per 100 000.	Per cent of all deaths.	Total.	Per 100 000 Population.	Per cent. of all deaths.	Total.	Per 100 000 Population.	Per cent of all deaths.
1879	11 000†	212	19.3	3	2	18	.94	25	227	11.8	91	828	43
1880	11 365	207	18.2	7	3	26	1.45	30	264	14.5	96	845	46
1881	11 690	205	17.5	3	2	17	.98	19	162	9.3	91	779	44
1882	12 010	230	19.2	6	8	67	3.48	20	166	8.7	88	732	38
1883	12 335	224	18.2	1	1	8	.45	25	200	11.2	95	772	43
1884	12 655	218	17.2	20	10	79	4.59	30	237	13.7	87	688	40
1885§	12 980	247	19.0	0	1	8	.40	24	185	8.9	119	911	48
1886	13 300	248	18.6	2	4	30	1.66	29	218	11.8	101	753	41
1887	13 625	270	19.9	10	4	30	1.48	33	243	12.2	118	868	44
1888	13 950	347	24.3	26	9	64	2.60	59	423	17.0	168	1 204	48
1889	14 270	233	16.3	No report	8	56	3.43	35	245	15.0	97	679	42
1890	14 590	288	19.7	"	4	27	1.39	49	336	17.0	135	925	47
1891	14 995	255	17.0	16	4	27	1.57	25	166	9.7	66	447	26
1892	15 400	306	19.2	27	7	45	2.27	56	363	18.3	127	825	41
1893	15 805	281	17.8	30	10	63	3.56	27	171	9.6	93	595	33
1894‖	16 210	290	17.9	4	2	12	.69	35	216	12.1	94	580	32
1895	16 615	291	17.5	15	1	6	.34	21	127	7.2	112	674	38
1896	17 020	360	21.2	6	4	24	1.11	45	265	12.3	153	893	42
1897	17 425	333	19.1	7	2	12	.60	44	254	13.2	123	706	37
1898¶	17 830	283	15.9	32	5	28	1.79	12	68	4.2	83	465	29
1899	18 235	348	19.1	33	2	11	.59	35	192	10.1	111	608	32
1900**	18 640	329	17.7	35	7	38	2.12	34	182	10.3	114	612	35
1901	19 045	326	17.2	22	5	26	1.53	34	178	10.4	123	646	38
1902	19 450	312	16.0	19	2	10	.64	25	128	.79	114	586	37
1903	19 855	379	19.0	29	3	15	.79	30	151	.79	116	584	31
1904	20 260	365	18.0	36	7	36	1.91	34	168	9.3	126	622	35
1905	20 665	434	21.0	32	3	15	.68	48	232	11.1	145	700	34

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* Population for intercensal years computed by the United States Census Bureau method; that is, by arithmetic increase between censuses.

† The population decreased about 3 000 from 1870 to 1880; the 1879 population used is arbitrary.

‡ Cases of typhoid cannot be compared with deaths, since the compiler has added to the typhoid deaths given in the annual health reports all deaths reported as bilious, continued, enteric, slow and typho-malarial fever. See footnote to Table 4, Deaths from Typhoid by Months.

§ Main outlet sewer shifted to point one-half mile farther from water intake, making a total distance of about one mile, but understand that storm overflow has been in use at old outlet ever since.

‖ New intake in use "several months" during 1894, apparently beginning in August. Main outlet sewer extended in 1894 to discharge at dock line, instead of into still water, virtually a settling basin, back of dock line.

¶ Late in 1898 a reservoir of nearly 4 000 000 gallons capacity was put in use, and the old reservoir, which was in great need of cleaning, was disconnected. Not stated whether used again before 1900.

** Old reservoir cleaned, repaired, and banks raised; capacity evidently increased from about 2 350 000 to 3 000 000 gallons, making a total capacity of about 7 000 000 gallons, not including high-service tank.

TABLE No. 2. — DEATHS FROM DIARRHEAL DISEASES AT BURLINGTON, VT., 1879 TO 1905, INCLUSIVE.

	CHOLERA INFANTUM.	CHOLERA MORBUS.	COLITIS.	DIARRHEA.*	DYSENTERY.*	ENTERITIS.	GASTRO-ENTERITIS.	ULCERATION BOWELS.	TOTAL.
1879	18	..	..	5		2	..	..	25
1880	20	..	..	7		3	..	..	30
1881	12	1	..	2		4	..	..	19
1882	7	3	1[1]	4		3	2	..	20
1883	8	..	..	5		12	..	..	25
1884	16	..	..	7		3	4	..	30
1885	13	..	..	..	1	8	2	..	24
1886	19	1	..	..	..	2	6	1	29
1887	15	4	..	..	2	4	8	..	33
1888	32	1	..	..	1	12	12	1	59
1889	13	..	9[1]	1	..	7	5	..	35
1890	26	..	6[1]	1	2	7	6	1	49
1891	14	..	3[1]	..	..	3	3	2	25
1892	37	2	..	3	..	6	7	1	56
1893	15	1	1[1]	2	1	2	5	..	27
1894	22	2	2[1]	..	1	4	3	1	35
1895	14	..	1[1]	2	2	1	1	..	21
1896	28	..	5[1]	5	2	4	1	..	45
1897	22	2	2[1]	2	1	8[2]	7	..	44
1898	3	..	..	3	1	2	2	1	12
1899	21	1	1[1]	1	..	8[2]	3	..	35
1900	20	1	2[1]	..	..	6	5	..	34
1901	21	1	3[1]	2	1	3	3	..	34
1902	17	..	1[1]	..	1	5	1	..	25
1903	17	..	3[1]	1	..	2	7	..	30
1904	19	..	5[3]	3	..	3	4	..	34
1905	17	..	4[1]	..	1	9	17	..	48

* From 1879 to 1884, inclusive, diarrhea and dysentery were not separately reported.

[1] Entero-colitis.

[2] Including one intestinal colic.

[3] Including one entero-colitis.

TABLE No. 2-A. — Deaths per 100 000 at Burlington, Vt., from All Causes, Typhoid Fever, Diarrheal Diseases and Deaths under Five Years, for those Years in which the Typhoid Death-Rate Exceeded 35 per 100 000.*

	All Causes.	Typhoid Fever.	Diarrheal Diseases.	Under Five Years.	Per Cent. Three Causes are of All Causes.
1882	1 920	67	166	732	50
1884	1 720	79	237	868	58
1888	2 430	64	423	1 204	68
1889	1 630	56	245	679	60
1892	1 920	45	363	825	65
1893	1 780	63	171	595	46
1900	1 770	38	182	612	47
1904	1 800	36	168	622	46
(1905†)	(2 100)	(15†)	(232)	(700)	(46)

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* In sixteen of the twenty-seven years from 1879 to 1905, inclusive, the typhoid mortality exceeded 20 per 100 000.

† 1905 inserted for comparison.

TABLE No. 3. — Death-Rates from All Causes and from Typhoid and other Diseases by Five-Year Periods before and after Extending Burlington Water-Works Intake.

	All Causes per 1 000.	Typhoid.		Diarrheal.		Under 5 Years.	
		Per 100 000.	Per cent. all deaths.	Per 100 000.	Per cent. all deaths.	Per 100 000.	Per cent. all deaths.
1879–83 ..	20.2	27	1.48	204	10.9	789	43
1884–88 ..	20.0	42	2.11	263	13.1	891	45
1889–93 ..	18.2	44	2.43	256	14.1	690	38
1894	17.8	12	.69	216	12.1	580	32
1895–99 ..	18.5	16	.86	182	9.8	668	36
1900–04 ..	17.6	25	1.40	161	9.2	609	35
1879–1904	18.4	29	1.58	208	11.2	708	38
1905	21.0	15	.68	232	11.1	700	34

TABLE No. 4. — MONTHLY DISTRIBUTION OF TYPHOID* MORTALITY AT BURLINGTON, VT., 1879 TO 1905, INCLUSIVE.

	JANUARY.	FEBRUARY.	MARCH.	APRIL.	MAY.	JUNE.	JULY.	AUGUST.	SEPTEMBER.	OCTOBER.	NOVEMBER.	DECEMBER.	TOTAL.*
1879..	..	..	..	..	1	..	..	..	..	..	..	1	2
1880..	..	1	..	..	1	..	1	..	..	..	..	..	3
1881 .	..	..	..	..	..	..	..	..	1	..	1	..	2
1882..	..	3	2	..	..	..	..	..	..	1	2	..	8
1883..	1	..	..	..	..	..	..	..	..	..	..	..	1
1884..	1	..	..	..	..	2	4	2	..	1	..	..	10
1885..	..	..	..	..	..	1	..	..	..	..	..	..	1 (1)
1886..	..	..	..	..	..	2	..	..	1	1	..	..	4 (2)
1887..	2	..	..	1	..	..	..	..	..	..	..	1	4 (2)
1888..	1	..	..	1	..	1	1	..	3	1	..	1	9 (5)
1889..	1	2	..	1	..	..	..	1	1	1	..	1	8 (2)
1890..	..	1	1	..	..	..	1	..	..	..	..	1	4 (3)
1891..	..	3	.	..	..	..	..	..	..	..	1	..	4
1892..	1	..	1	..	..	..	..	1	..	2	1	1	7 (4)
1893..	1	4	2	..	1	..	..	1	1	..	..	..	10 (2)
1894..	..	1	..	..	..	..	..	1	..	..	..	..	2 (1)
1895..	..	..	..	..	..	..	1	..	..	..	..	..	1
1896..	..	1	..	..	..	1	1	1	..	..	..	..	4 (3)
1897..	..	..	..	..	..	1	1	..	..	..	..	..	2 (1)
1898..	1	1	1	..	..	..	..	..	1	1	..	..	5 (1)
1899..	..	..	1	..	..	..	..	1	..	..	..	..	2 (1)
1900..	2	2	..	..	..	..	..	..	1	1	..	1	7
1901..	1	..	2	1	..	..	..	..	..	..	1	..	5 (1)
1902..	..	..	..	1	..	..	..	..	..	..	..	1	2
1903..	..	..	..	..	1	1	..	1	..	..	..	..	3
1904..	..	..	1	..	..	1	2	..	1	1	1	..	7
1905..	1	..	1	..	..	..	..	..	..	..	..	1	3
Total	13	19	12	5	4	10	12	9	10	10	7	9	120 (29)

* Included in the typhoid mortality as here given are, for the whole period, 29 cases classed in the city reports as bilious and other fevers. The totals by years are given in parentheses at the right in the last column; in detail they are as follows:

1885. — 1 typho-malarial fever in June.
1886. — 1 bilious fever in June; 1 slow fever in September.
1887. — 1 typho-malarial in May and 1 in December.
1888. — 1 continued fever in April, 1 in July, 2 in September, 1 in October.
1889. — 1 continued in February; 1 enteric fever in April.
1890. — 1 continued in July; 1 typho-malarial in March and 1 in December.
1892. — 1 continued in January and 1 in December; 1 enteric in October; 1 typho-malarial in August.
1893. — 1 bilious in February; 1 continued in March.
1894. — 1 bilious in August.
1896. — 1 continued in August; 1 typho-malarial in February and 1 in June.
1897. — 1 bilious in June.
1898. — 1 bilious in October.
1899. — 1 bilious in August.
1901. — 1 bilious in January.
1885 to 1901: Continuous, 11; typho-malarial, 8; bilious, 7; enteric, 2; slow, 1.

The deaths classed as typhoid in the above table have been rearranged by months from highest to lowest, as follows: February, 19; January, 13; July, 12; March, 12; June, 10; September, 10; October, 10; August, 9; December, 9; November, 7; April, 5; May, 4; total, 120. The monthly mass average is 10.

By quarterly periods the grouping, from highest to lowest, is: January–March, 44; July–September, 31; October–December, 26; April–June, 19; total, 120.

TABLE No. 5. — BURLINGTON WATER ANALYSES AVERAGED BY YEARS.

(Chemical results in parts per 1 000 000; bacterial in 1 c. c.)

	NUMBER OF SAMPLES.	BACTERIA.		CHLORINE.	AMMONIA.	
		Total.	Coli Present.		Free.	Albuminoid.
1899	27	268	Not reported	1.4	.031	.141
1900	38	529	Not reported	2.3	.039	.139
1901	24	1 293	7 of 24	.9	.021	.134
1902	66	617	13 of 65	1.1	.014	.115
1903	49	641	8 of 49	1.1	.011	.113
1904	50	782	13 of 49	1.0	.012	.114
1905	49	172	12 of 49	1.1	.014	.121

The nitrates and nitrites were first reported in 1903. The nitrates have been as follows, in parts per million: 1903, .190; 1904, .180; 1905, .187. No nitrites were found during these three years.

The total solids for 39 samples collected during 1905 ranged from 95 parts per million on October 11 (the last sample for the year), with a loss on ignition of 37, to 58.5 parts on May 5, with a loss on ignition of 14. The maximum figure given was abnormal, 75 having been exceeded only five times.

The chlorine for the least polluted portions of Lake Champlain does not seem to have been determined. Water Supply and Irrigation Paper No. 144 (United States Geological Survey) shows the lake lying between Isochlors 0.3 and 0.4 (parts per million), but the normal chlorines of waters in towns near the lake, in the vicinity of Burlington, average about 0.5. The range of chlorine found in the samples included in the above table has been from 0.4 to 3.4. By years this range has been: 1899, 0.6 to 2.0; 1900, 1.6 to 3.4; 1901, 0.4 to 1.4; 1902, 0.8 to 1.5; 1903, 0.9 to 1.4; 1904, 0.8 to 1.3; 1905, 0.9 to 1.3. The 3.4 figure, like a number of others for 1900, was for a sample drawn from one of the reservoirs.

See Professor Sedgwick's paper (JOURNAL OF NEW ENGLAND WATER WORKS ASSOCIATION, Vol. X, p. 174) for 28 analyses, mostly of samples from various points in the lake, made from 1882 to 1889, inclusive.

TABLE No. 6. — B. COLI COMMUNIS IN DAILY SAMPLES OF WATER FROM THE BURLINGTON WATER SUPPLY, FEBRUARY, 1904, TO JANUARY, 1905, INCLUSIVE.

(Examinations of 1 cc. of water made at the Vermont State Laboratory of Hygiene. B. H. Stone, M.D., Director and Bacteriologist; P. S. Carpenter, Assistant Bacteriologist.)

Month 1904-5.	Number of Daily Samples.	Per Cent. of Samples Positive.	Month.	Percentages Rearranged, Greatest to Least.
February	29	34	December	60
March	31	45	January	57
April	30	36	October	53
May	29	51	May	51
June	28	51	June	51
July	28	25	March	45
August	31	31	April	36
September	16*	31	February	34
October	31	53	November	33
November	30	33	August	31
December	28	60	September	31
January	26	57	July	25
Year	337	44†	Year	44†

* Vacation taken this month.

† Percentage for year based on totals for the year and not merely an average of the monthly percentages; that is, of the 337 samples examined, 147, or 44 per cent., gave positive results.

TABLE No. 7. — LENGTHS IN MILES OF STREETS, SEWERS, WATER MAINS, AND ALSO POPULATIONS AND WATER CONSUMPTION, BURLINGTON, VT., AT STATED INTERVALS.

	LENGTH IN MILES OF			POPULATION.	AVERAGE DAILY Water Consumption, Gals.	
	Streets.	Sewers.	Water Mains.		Total.	Per Capita.
1880	(50*)	6.14	(20*)	11 365	600 000	53
1885	...	8.54	28.7‡	12 980	621 812	48
1890	53.0	14.07	30.4‡	14 590	756 401	52
1895	54.9	18.76	35.7‡	16 615	888 083	53
1900	55.5	23.91	38.0‡	18 640	857 250	46
1904	56.6	27.50	40.0‡	20 260	987 158	49
1905	56.9†	28.20	40.0‡	20 665	1 056 008	51

* In 1882 ; not reported in 1880.

† Paved and macadamized, 22.8 miles; graveled, 17.1 miles.

‡ Not including pipe under 4 inches in diameter, which was 5.8 miles in 1885 and 4.8 in 1905.

The present water works were put in operation on December 25, 1867. Mention of the " present sewer " was made in the annual report for the year ending February 1, 1868.

An unusually high percentage of the total population has been supplied with water for many years, according to the annual reports of the water department. As early as 1885 it was estimated by the water department that all but 700 of the population was supplied with city water; in 1905 the unsupplied population was likewise given as only 400. The number of taps or services at the close of 1905 was 3 634, or over 1 per 6 of estimated population; at the same time there were 2 867 meters in use, or 79 per cent. of the total number of taps.

DISCUSSION.

MR. ROBERT S. WESTON.* *Mr. President and Gentlemen of the Association,*— The speaker had the good fortune to look over Mr. Baker's paper in advance. It certainly is a piece of very serious and very careful work. Last night some here enjoyed the privilege of listening to Mr. Baker's after-dinner speech at the annual dinner of the Boston Society of Civil Engineers, in which he took occasion to plead for a broader training for engineers and a more thorough study of engineering problems, especially of sanitary engineering problems, saying that these questions should be studied statistically and not *a priori*.

Such suggestions are very timely, especially when one considers that progress in sanitary science must be based upon vital statistics and that vital statistics are often grossly inaccurate. One has heard of the scholar in politics and the scholar in art; in this paper Mr. Baker expresses the life of the scholar in sanitary science.

In looking over this paper it is especially interesting to note how many more infants there are who die from diarrheal diseases than there are people who suffer death from typhoid fever. The ratio is something like 20 to 1. If these other diarrheal diseases were statistically treated, so that they could be given engineering notice, they would certainly be a worthy subject for frequent discussion in connection with the purity of our water supplies. Health officers frequently say: " Why do engineers always harp upon the typhoid fever death-rate? " And engineers reply: " That is the only group of vital statistics which we can treat as a reality, as a basis for any definite engineering work and expenditure of money." It is certainly very gratifying to read Mr. Baker's scholarly research into the vital statistics and his attempt to solidify the basis for the design and construction, operation, and protection of water supplies.

In this connection it is quite interesting to remember Mr. Hazen's remarks at the International Engineering Congress at St. Louis, when he said that the experience in Albany and in several other cities which he had studied, was that for every reduction of 1 per 100 000 in the typhoid fever death-rate, there seemed to be a corresponding reduction of 3 or 4 in the general death-rate. That, if true, certainly would be in confirmation of Mr. Baker's paper.

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* Sanitary Expert, Boston, Mass.

Two things are quite noticeable at Burlington. *First*, there is a rather uniform distribution of typhoid fever throughout the year, while in many other cities typhoid fever seems to reach its height in the fall. This would point to the absence of what one calls vacation typhoid, and to the existence of typhoid due to local causes. *Second*, the water, even though polluted, is of agreeable appearance, so that the whole community partakes of it and does not, as they do in many other cities, resort to spring and well waters of doubtful history. The problem at Burlington is uncomplicated by such side issues as these.

There are two fallacies in regard to the public health, which, in the speaker's opinion, would be exposed by the public health statistics; namely, what for lack of better terms may be termed the hospital fallacy and the prosperity fallacy. One frequently hears people say, as is written in Mr. Baker's paper with a question mark: "Our city has a higher typhoid fever death-rate in comparison with other cities because we have a hospital in our city; because this hospital draws upon the surrounding country for patients, and because the deaths of these out-of-town patients are included in the statistics." In opposition to this idea one should remember that many people go away from home and die of typhoid fever. One should also remember that every large center of population has a hospital, and naturally every large center of population draws upon the surrounding country for the support of that hospital. Even in suburban towns and cities there are hospitals,— Waltham, Newton, Brockton, Fall River, Taunton, Lowell, Lawrence, all have hospitals, — and in comparing statistics we are comparing the statistics of cities in all of which there are hospitals. Therefore it does not seem to the speaker that the health officer is justified, when he speaks about the typhoid fever death-rate in a city, in excusing lack of sanitary excellence because of the presence of a hospital, unless all the figures are given.

Then there is another fallacy, which may be called the prosperity fallacy, which is this : People say, "Our community is a very prosperous community, a rich community, and every summer a large number of people go away on vacations, and when they come home they bring typhoid with them. This typhoid fever is not due to conditions in our city, but it is due to the conditions of the summer vacation." There is a great deal of truth in this statement, of course, but the speaker does not think it explains everything by any means (for example, why the wealthy cities frequently have low typhoid), and urges that in studying public health questions the statistical method be used,— but not the statistical method which Dr. Carroll D. Wright exemplifies when he says, " Statistics do not lie, but statisticians sometimes do."

It is a great pleasure to praise Mr. Baker's work and his paper, both for their scientific spirit and their spirit of public service.

Prof. C.-E. A. Winslow.* I have listened with very great pleasure to Mr. Baker's paper, not only for the results which have been obtained, but also as a study in method to be pursued. This is one of those cases where the damage was of the kind that could not be detected and proved by any gross methods. It needed the careful use of statistics and the careful analyses of bacteriological and chemical data to prove it; but it has been proven here, I think, without a shadow of a doubt. Of course statistics are difficult things to handle. In the first place, in this country there are only a comparatively few cities and towns that have good vital statistics; and in the second place, statistics require expert skill and care in handling after they are collected. When, as in this case, you have statistics which have been well collected, and which are ably analyzed, you are on safe ground. One table which Mr. Baker has been good enough to let me look over shows the typhoid deaths by months for a period of years, and I think an inspection of that table alone would be enough to convince any one familiar with typhoid fever that most of the typhoid in Burlington is due to the water supply. In the first place, if milk epidemics were important, the typhoid deaths would be grouped together, a considerable number in a single month, because a milk epidemic almost always effects a considerable number of people at the same time. That is not the case here. The deaths occur two or three at a time only, and there are no large epidemics. In the second place, the point to which Mr. Weston alluded is not significant, the typhoid deaths being rather evenly distributed over the year, showing even, as Mr. Weston did not state, a slight concentration in the winter and in the early spring.

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* Massachusetts Institute of Technology, Boston, Mass.

Now, as Professor Sedgwick has pointed out at a previous meeting of this association, there is a clear distinction between the distribution of typhoid fever by seasons, when it is due to water and when it is not. When typhoid fever is due to causes other than water it has a regular seasonal curve. The typhoid germ is quite susceptible to the temperature, and in cities not having a polluted water supply the disease increases in the autumn, reaching its height in September and October. That is almost an invariable rule, as has been shown by the study of statistics all over the globe. On the other hand, where you have a polluted water supply, typhoid deaths are most apt to occur in the winter, not in midwinter, but at the beginning of the winter when there are heavy rains, and at the end of winter when the thaws come, because those are the times of flood when most polluting material is washed into the water supply. The figures for Burlington show exactly that distribution, and there can be no doubt that the typhoid deaths are due mainly to the water supply.

Again, I think this paper furnishes very valuable testimony as to the importance of bacteriological analyses. The commonly accepted standard is that water which is good to drink should not give a positive test for the colon bacillus in one cubic centimeter certainly not over 50 per cent. of the time. We have lacked data to enable us to fix the standard very closely, but that has been considered a conservative estimate. This paper suggests that perhaps that estimate is a little too high. The analyses in Burlington, where there was a slight pollution, and only a slight pollution, when compared with the water supplies of Philadelphia and Pittsburg, and many other cities, show the colon bacillus in about 40 per cent. of the samples, I think. This shows that we certainly have not been too stringent in insisting upon the 50 per cent. limit, and it suggests that we should probably insist on still greater purity.

There is just one other point I should like to say a word about, and that is the very important question of the deaths of young children, to which Mr. Baker has alluded. Very few people who have not studied vital statistics realize the importance of this factor in the death-rate, or comprehend that in some communities from 30 to 40 per cent. of the total deaths occur under five years of age. That is the case in many of our large cities, and it is the case in Burlington. It means that perhaps a fifth or two fifths of the children born are swept out of existence before they are five years of age. I do not think that any large part of this death-rate can be attributed to water. In the first place, the deaths are largely of children under one year; and it has been shown by extensive studies in Germany and elsewhere that for the most part this death-rate is due to milk, and to cow's milk, and to rotten cow's milk, — that is, it is due to a poisoning from the putrefaction of cow's milk before the children are fed upon it. But whatever it is due to, it certainly behooves every one to see that the matter is properly studied.

I believe that a great deal can be gained by inciting, as Mr. Baker has apparently wished to do, boards of water-works officials to watch health boards. Health boards already exercise a pretty close supervision over water-works officials, but I think the rule should work the other way, too. It seems to me that every public-spirited citizen, and certainly every water-works official, should study the vital statistics in his own town and find out if there is an excessive death-rate among children. If water is not the cause, he should get after the health board, the proper officials, the people who should supervise the milk supply, and other sanitary dangers, and have them see to it that conditions are remedied.

B. H. STONE, M.D.* It is with much hesitation that I venture to discuss a paper which I have not had the opportunity of hearing, and probably some things which I say would remain unsaid if that opportunity had been mine. I am, however, fairly familiar with Mr. Baker's views of the Burlington water question as expressed in his report prepared for the Special Water Committee appointed to consider the question of a new supply. With most of the views expressed in that report I am in accord. There are a few features of the situation which Mr. Baker passes over as of little importance, to which we at the Laboratory of Hygiene are inclined to give more weight. Mr. Baker suggests that the discussion be along the following lines:

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* Laboratory of Hygiene, Burlington, Vt.

1. Leakage of intake pipes and analytical means of detecting it.
2. Dangers from the sewage of Burlington as compared with that of Winooski and Fort Ethan Allen.
3. Typhoid records at Winooski and Fort Ethan Allen.
4. Typhoid at the Mary Fletcher Hospital.
5. Influence of out-of-town inmates at the hospital and two children's homes upon the general death-rate and other mortality figures as given in Table No. 1.

In regard to the first point, little can be said from the sanitary aspect beyond what has already been said. We have, so far as I know, no analytical data to prove such an accident. Specimens of water taken over our own intake resemble very closely those taken from our service pipes. On the other hand, it is perfectly evident from the slight analytical difference between water taken in the region of the intake and much nearer shore, as is brought out in Mr. Leighton's paper on the "Pollution of Lake Champlain," that a large admixture of shore water would be possible without any appreciable analytical change to prove its presence. This problem seems to me to be one which must be attacked from an engineering rather than from a sanitary standpoint.

With regard to the second point suggested by Mr. Baker for discussion, *i. e.*, the dangers from the sewage of Burlington as compared with that of Winooski and Fort Ethan Allen, I must take some exception. Mr. Baker passes over the Winooski River as of little importance in the Burlington water problem, while we are convinced that it is a factor of real importance, and perhaps the most dangerous source of infection to our water supply. Our grounds for this opinion are based upon the following propositions which we think are capable of proof :

1. That Winooski and Fort Ethan Allen pour into the river the raw sewage of a population of approximately 5 500.
2. That the topography of the region is such as to render it possible, and even probable, that some portion of this sewage may reach this intake.

3. That we have optical evidence that our water is affected by the river at times of flood.

4. That there is an increase of diarrheal diseases following high water in the Winooski River.

The population of Winooski has increased very materially since the new intake was put in operation in 1894, and Fort Ethan Allen, with its population of 1 500, has been established since that date. This post was first occupied in 1894, when three troops of cavalry arrived there. Since that time it has gradually increased in size, until now it is the second largest military post in the United States, having a continuous population of about 1 500 men. The Winooski River receives the sewage from this post a short distance above Winooski. That the water is highly polluted when it reaches Winooski is amply proven by a large amount of analytical data, some of which is published in Mr. Leighton's paper and some of which appears in the various reports of the Vermont State Board of Health. A striking evidence of the danger of this pollution was brought out by a recent experience in the village. One year ago this winter the Winooski water supply proved insufficient and arrangements were made to use the Burlington water. There was some delay in making the connections and the authorities were forced to allow the untreated river water to flow through the pipes for about twenty-four hours; although people were warned against drinking it, some twelve or fifteen cases of typhoid occurred within the next two weeks.

Float work which has been done by Professor Votey, although not yet completed, shows that the time required for water to pass from Fort Ethan Allen to the mouth of the river is in the vicinity of seventeen hours. The distance from the village of Winooski to the mouth of the river is not over two miles, but on account of its tortuous course, the river flows nearly ten miles in making that distance. In spite of this, the water at the mouth of the river is badly polluted, as has been proven by analytical data taken at various seasons of the year through the ice and in the summer months. This pollution can be traced analytically for a considerable distance from the mouth of the river. The current of the river at its mouth is south. The shore currents of the lake inside the promontories, as proven by Mr. Leighton, are southern.

From the mouth of the river to the intake the distance is about three miles. For 2¾ miles of this distance the water is nowhere over ten feet in depth, and for the last quarter of a mile not over twenty-five feet. Now at times of low water it is probably very true. as suggested by Mr. Baker, that the sewage from Fort Ethan Allen and Winooski is largely taken care of by sedimentation and other natural causes, but in times of high water these causes are not in operation, and the highly polluted waters rush over the sand flats at the mouth of the river, strike the southern lake currents, and are carried directly over the region of our intake. That this is true is plainly demonstrable after such a period of high water. At such a time the line of muddy water can be noted passing almost as far south as Juniper Island and circling around Apple Tree Point over the intake. A photograph which I enclose * shows this rather poorly. At such times drift wood coming from above Fort Ethan Allen as far up as Essex Junction is found, from twelve to twenty-four hours after, strewn along the shores of Sunset Bay, having passed the entire distance down the river and over the intake in this time. After such a period of high water, the water coming into our reservoir and passing through our service pipes shows a decided increase in turbidity for several days. That this muddy water carries with it sewage organisms is plainly evident from the fact that we are always able to detect the colon bacillus from our service pipes at such a time, and that such high water is invariably followed by an unusual number of cases of typhoid and diarrhea. Such an occurrence happened this winter following one of our rapid thaws. The water was so muddy that a very perceptible sediment would collect in the bottom of a glass. In the next two weeks there were eight or ten cases of typhoid, and diarrhea was almost universal. At times of high water, of course, the dilution of sewage is great; but sedimentation does not take place, and the rapidity of the flow is so much greater that the reduction by dilution is more than compensated. Furthermore, in such a time of thaw, much filth which has accumulated on the frozen ground is washed into the river. Although the fact of this great dilution will probably prevent any considerable epidemic of typhoid at such times, we believe that in its present position

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* Not reproduced. — Ed.

our intake is more in danger by this source of pollution than by Burlington sewage. It is rather a strange coincidence that Fort Ethan Allen was established on the Winooski River, increasing this so materially as a source of contamination, in the same year that our intake was removed so much nearer to the mouth of this river.

Burlington sewage, barring the effect of the winds, is influenced by the general southern shore currents of the lake which sweep it south into and by Shelburne Bay, where it circles north again between Burlington and Juniper Island, when it is separated from the intake by two miles of deep and comparatively still water. Sedimentation is much more operative here than in the moving waters of the river. In the specimens taken by Mr. Leighton and examined in this laboratory, some specimens taken in the deep water on the line between the mouth of Shelburne Harbor and the intake showed no colon bacilli, and showed a water quite nearly like the normal water of the broad lake.

I am enclosing the typhoid and diarrhea statistics from the hospital at Fort Ethan Allen. (Table No. 8.) I was unable to procure satisfactory statistics from Winooski. I am also enclosing a table which shows the number of cases from Burlington which have been examined for typhoid by the Widal reaction at this laboratory. (Table No. 9.) I have given figures for the positive and negative cases, as those which failed to give the reaction would naturally come under the diarrheal diseases. It will be noted that the number of positive cases in every instance is larger than the number reported to the health officer. This indicates in my mind that a good many cases of genuine typhoid are probably not reported.

I am inclined to think that the out-of-town typhoid cases which are treated at the hospitals and the two homes are of very little importance, as all of these institutions avoid taking these cases, and when so taken they appear on the reports.

TABLE No. 8.—STATISTICS OF TYPHOID FEVER AND DIARRHEA AT FORT ETHAN ALLEN.

Year.	1906	1905	1904	1903	1902	1901	1900	1899	1898*	1897	1896	1895	1894
Typhoid	—	3	1	1	—	1	—	1	6	—	1	1	4
Dysentery	—	1	—	4	3	5	—	1	6	—	1	—	—
Diarrhea	7	23	41	24	40	31	—	24	47	17	15	6	5

* In the fall months of this year (1898);the First Vermont Volunteers were stationed here, coming from Camp Thomas. During the time of their stay there were fifty-five (55) cases of typhoid treated at the Post Hospital. These cases do not appear in the above table.

The case of dysentery noted (1905) was acquired in Philippine Islands.

This excerpt from Post Hospital records dates from October 1, 1894, to present month of March.

All records for the volunteer forces stationed here at any time have been sent to surgeon-general's office, Washington, D. C.

C. R. ROBBINS,
Captain and Assistant Surgeon, U. S. A.

TABLE No. 9.—BURLINGTON FEVER CASES WHICH HAVE BEEN SUBJECTED TO THE WIDAL TEST AT THE LABORATORY OF HYGIENE, BURLINGTON, VT.

Year.	Positive.	Negative.	Year.	Positive.	Negative.
1898	41	31	1902	20	24
1899	43	22	1903	29	68
1900	52	34	1904	56	32
1901	37	54	1905	77	113

MR. C. P. MOAT.* Since any statement of my opinion on the question of the influence of the Winooski River on the intake of the Burlington water works would be simply a repetition of Dr. Stone's remarks, as our ideas on this question have always been in full accord, I will simply submit some additional data on the quality of the water of the Winooski River. In addition, I send as much information on the number of cases of typhoid fever in the village of Winooski as is at present available (Table No. 10).

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* Chemist, Vermont State Board of Health, Burlington, Vt.

These data are taken from the number of specimens sent to the Laboratory of Hygiene for the Widal test and are probably more accurate than the number of cases reported to the health officer, which is not available at this time.

In the table of water analyses (Table No. 11), the samples were taken from the Winooski River in the following places:

I. Several hundred feet above the outlet of the sewer of Fort Ethan Allen.

II. Below the outlet of the sewer of the fort (sample was taken near shore and current of river was towards that shore).

III. Above the upper dam at the village of Winooski.

IV. Below the village of Winooski. (Sample was discolored and contained very high chlorine, probably caused in part by mill waste, but as yet we have had no opportunity for further study of this problem. We hope to do more along this line this spring.)

V. Sample taken at the temporary intake of the Winooski Aqueduct Company at the American Woolen Company's mill at village of Winooski. This sample was taken at the time mentioned by Dr. Stone, when the river water was allowed in the mains of the Winooski Aqueduct Company for twenty-four hours, causing much typhoid, as shown in year 1903-4 of Winooski typhoid table.

VI. Sample taken at railroad bridge near the mouth of Winooski River.

Besides these analyses, further data may be found in the Water Supply Paper, United States Geological Survey No. 121, Tables xxii and xxiii and Fig. 7.

TABLE No. 10.—Specimens Examined at Laboratory of Hygiene for Typhoid from Winooski.

Year.	Results.		
	Positive.	Negative.	Total.
Nov. 1, 1898 - Dec. 1, 1900,	5	11	16
1900–1901	6	16	22
1901–1902	2	7	9
1902–1903	4	9	13
1903–1904	18	38	56*
1904–1905	7	18	25

* Year in which river water was used for twenty-four hours.

TABLE No. 11.—ANALYSES OF WATER FROM WINOOSKI RIVER. (PARTS IN 1 000 000.)

	DATE OF COLLECTION.	APPEARANCE.			ODOR.		RESIDUE ON EVAPORATION.			AMMONIA.		Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.	Bact. per 1cc	B. Coli.
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition	Fixed	Free.	Albuminoid. Total.		Nitrates.	Nitrites.				
I	Nov., 1905	sl.	sl.	14	1e.	—	71.	20.	—	.008	.106	.7	.230	.000	—	41.6	300	present
II	Dec., 1905	dec.	„	12	5d.	—	60.	10.	—	.150	.250	1.4	.250	.000	—	——	420	„
III	Nov., 1905	sl.	„	24	2e.	—	70.	10.	—	.010	.098	1.1	.200	.000	—	41.6	500	„
IV	„ „	„	„	30*	„	—	82.	22.	—	.044	.116	3.5	.140	.000	—	48.6	400	„
V	Jan., 1904	dist.	„	30	3e.	—	87.5	11.5	—	.076	.100	1.6	.600	.003	—	62.9	1 000	„
VI	Mar., 1901	dec.	cons.	30	2v.	—	54.8	14.	—	.068	.194	1.6	.340	.001	—	36.	many	„

* Discolored.

MR. M. O. LEIGHTON.* The subject of this paper is of great interest to the writer. During the summer of 1904 he had occasion to look into it to some extent in connection with an investigation maintained by the United States Geological Survey upon the pollution of Lake Champlain. Among the results of that investigation was a demonstration of the fact that, although the water in the broad lake did not contain bacillus coli communis, the entire area in front of the city of Burlington, and from thence northward to and beyond Apple Tree Reef, the point of the present intake, was infected by Burlington sewage. This was shown by the almost constant appearance of coli in the samples collected.

Mr. Baker's first table shows that, although no relation is apparent between the total deaths and the number of deaths from typhoid, the number due to diarrheal diseases appears to fluctuate with the total in an extremely interesting manner. The large number of fatalities from diarrheal diseases is a distinct factor in increasing the general death-rate at Burlington.

Another interesting fact shown by Table No. 1 is the apparent faithfulness with which the cases of typhoid fever have been reported in Burlington since 1898. The writer is now referring to those cases which are well marked and easily diagnosed and recognized by the practitioner. It appears from a review of the report of the Medical Commission appointed to investigate the origin and spread of typhoid fever in the United States military camps during the Spanish War, that 7.61 per cent. of the typhoid cases were fatal, while American hospital experience in general seems to show that about 9.25 per cent. are fatal. Assuming that 8 per cent. is a conservative figure, it will be seen that there is an unusual faithfulness on the part of the physicians in reporting typhoid cases, the reports in some years being equal to the probable actual cases as comported upon this basis.

Of course we know that a great many of the deaths reported as being due to diarrheal diseases were actually the result of typhoid, and if the numbers were known, they would probably constitute a surprising proportion of the whole. It will be remembered that the investigation of the Medical Commission above referred to showed that the army surgeons diagnosed about one half the cases of typhoid fever in military hospitals during the Spanish War, and it has not been shown that physicians in civil life betray a much greater degree of success in general diagnostic ability than those in the army.

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* Chief of Division of Hydro-Economics, United States Geological Survey, Washington, D. C.

Another interesting point emphasized by Table No. 1 is that every important change that has been made in the sewerage and water-supply systems of Burlington has been followed by a marked reduction in either the number of deaths from typhoid or from diarrheal diseases, and it illustrates how misleading may be the statistics of a single year or of a short period. It will be noted in Table No. 1 that there were 79 deaths per 100 000 from typhoid in 1884, but in 1885, the date when the main outlet sewer was moved one-half mile farther away from the water intake, there were only 8 deaths per 100 000. Similarly, in 1894, the year after the removal of the water intake from the northern dock limit in the city out to Apple Tree Reef, there was a reduction in the number of typhoid deaths of from 63 to 12 per 100 000, and this reduction, by the way, persisted for several years. It is further particularly interesting to note that, in 1898, the date of the placing in commission of the new storage reservoir, there followed an enormous reduction in the deaths from diarrheal diseases. It appears that none of these changes have effected a permanent benefit in Burlington, and yet, if the statistics immediately following the dates of those changes be taken alone, wondrously deceptive statements may be made.

Mr. Baker's Table No. 2 shows that among the fatal diarrheal diseases, cholera infantum comprises a very large proportion. Presumably, this infantile trouble is due in only a minute degree to the public water supply, and the deaths probably all occurred during the hot months. It would be interesting to have a statement of the seasonal distribution of the deaths from these diseases, because it is especially important to know whether the greater proportion of them, other than cholera infantum, occurred during the winter months; when the lake is coated with ice. If such is the case, the evidence against the water supply would be even more conclusive than it appears from the results presented. It would be interesting, too, to compare the diarrheal morbidity in Burlington during the winter season with that in Michigan City, Ind., where each winter, up to the time that the Chicago sewage was diverted from Lake Michigan, they had an epidemic of what was locally known as "winter cholera," due undoubtedly to the infection of the lake supply by Chicago sewage. The infection was rapidly transmitted along the south shore of the lake by prevailing northerly winds and confined and concentrated under the ice sheet which usually forms there.

In connection with Table No. 2-A, which shows that during about one third of the time since the year 1880 Burlington has had an abnormal typhoid rate, it is interesting to notice that all the abnormal years, except two, occur previous to the extension of the water intake to Apple Tree Reef. From 1880 to 1894, abnormal typhoid rates appear about every second or third year, but during the eleven years subsequent to this extension, the rate has been abnormal during two years only. The same condition is exemplified in the deaths from diarrheal diseases. Accepting the rate of 20 per 100 000 as an arbitrary division between normal and abnormal diarrheal disease death-rates, it will be seen from an examination of Table No. 1 that during the years up to 1894, the abnormal death-rate largely predominated, while since that time the abnormal rate has appeared only on three occasions.

Table No. 3 emphasizes the improvement brought about by the extension of the conduit in the year 1894, and shows clearly the gradual return to the old conditions during more recent years. Why, in the lapse of years since the extension of the intake, there should have been a gradual return to former conditions, is a question which can hardly be answered with the present information. There are some reasons for believing that the continued discharge of Burlington sewage into the lake has increased the infected area until it now reaches to the intake at Apple Tree Reef. The series of samples taken in front of Burlington in September, 1904, along the line shown in Fig. 7, page 87, of Water Supply and Irrigation Paper No. 121, United States Geological Survey, would seem to indicate a very general extension of the infected area, coli communis being present in nearly all samples. That this is not a natural condition is shown, as stated at the beginning of this discussion, by the fact that in the broad lake, coli communis does not appear to be present.

There is also some reason for believing that the conduit extending from the pumping station to Apple Tree Reef may have developed leaks, which are responsible for a return of the old conditions of typhoid and diarrheal morbidity. This matter could and should be thoroughly investigated. The conditions of the investigation are such that the work would have to be directed along bacteriological lines and, in fact, just here is presented one of the unmistakable cases in which the value of bacteriology in connection with water investigation is shown. In order that the work may be of value and the results be made dependable, special preparations should be made, and a competent man should give his entire attention to every detail of the investigation.

Daily and, if possible, semi-daily samples should be taken from the mouth of the intake at Apple Tree Reef and from some point along the conduit after it emerges from the lake, possibly at the pumping station. These samples should be taken in series. Bacterial counts and tests for coli communis should be made, and a comparison of the two series should show conclusively whether or not the conduit admits infected water through leaks developed since the laying thereof. Besides being of immense local value, such an investigation would be of interest from a general scientific standpoint and would be useful reference for all future water investigations of a like character.

One of the most important evidences concerning the culpability of the water with reference to the production of typhoid in Burlington is contained in Table No. 6. It is especially significant that the highest typhoid rates occur during the season when the lake is covered with ice, when there is, one might say, a short circuit between the sewer outlet and the water intake. If we examine the seasonal distribution of urban typhoid throughout the United States, it will be found that quarterly periods from highest to lowest are (1) September to November; (2) December to February; (3) June to August; and (4) March to May; while, according to Mr. Baker's groupings, the highest quarterly period at Burlington is January to March, during which season Lake Champlain is generally coated with ice.

Mr. Baker's Table No. 5 affords a concrete illustration of the value of coli tests in revealing dangerous pollution in a water, while, on the other hand, the general futility of the nitrogen determinations for such purposes is amply demonstrated. In fact, throughout all the Burlington investigations, the nitrogen determinations have been of no aid in tracing the cause of disease and, as a whole, the case forms one of the best of a great many which demonstrate the general uselessness of the time-honored determinations of free and albuminoid ammonia, nitrites and nitrates, in surface water investigations.

Mr. Baker's observation that the pollution of Winooski River has probably very little to do with the infection of the water supply is supported to a large extent by observations of the writer. There are times, however, during seasons of prevailing northerly winds and of floods in the Winooski, when the path of the stream may be clearly marked along a course extending well to the south and not far from the present water intake. The general trend of the current, however, is northward from Winooski River, and it is therefore probable that such infection does not, in the majority of cases, extend as far south as Apple Tree Reef.

MR. ALLEN HAZEN.* Mr. Baker's paper is an extremely interesting contribution to our knowledge of the relations between water supply and public health. The most unfortunate feature connected with the case is the uncertainty as to whether the intake is tight, and whether all the water comes from the intended place, or whether there are leaks in the pipe line which admit more highly polluted water from the bay; and it seems particularly unfortunate that this matter was not settled beyond question before Mr. Baker completed his studies and made his report.

Mr. Baker has referred to the investigations of the use of polluted water by cities, made twelve or fifteen years ago, in making which I had the privilege of being associated with our honored President, Professor Sedgwick. The change that has taken place since that time in the aspects of this question is a most significant commentary on the development in the interval; and I wish to make a few comparisons which may help us to realize the extent of the progress which has been made.

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* Civil Engineer, New York, N. Y.

At the time mentioned, the relations between public water supply and disease were by no means generally recognized. And this is the more surprising, as many of the larger American cities were using grossly polluted waters, and as a result suffered from death-rates greatly in excess of what they would otherwise have had.

The question as to the accuracy of the vital statistics at our disposal then was far greater than it is now, but the effect of the polluted waters upon the health of the communities using them was so great that no refinements were necessary to bring out the general relations which existed. The contrasts between the large cities using different kinds of water were so great that it was hardly conceivable that errors in classification or in failures to report deaths, however flagrant they might have been, would have sufficed to modify the conclusion that the enormous excess of sickness and death in some American cities was directly due to the use of grossly polluted water supplies.

These conclusions, nevertheless, were at first bitterly contested in many quarters; but as they were studied further the logic of the situation became apparent, and they came to be generally accepted. Since then affairs have changed; and while there are still some black sheep in the fold, on the whole there has been a great improvement in the average quality of the public water supplies of the country, and the recognition of the relation between the character of the water supply and the health of the community has been a tremendously important element in bringing about this improvement.

At that time such an investigation and analysis as Mr. Baker has now made of the pollution of the Burlington water supply would have been out of place. Then it would have been difficult, perhaps impossible, to have established the relations between the moderate pollution of the water and the moderate increase in the death-rate from certain causes resulting from it, which Mr. Baker has found to exist in Burlington. Now it is possible. It is possible because, in the first place, the proposition that such a relation does exist is a corollary of the main proposition that highly polluted waters do produce excessive death-rates; and it is further possible because, in spite of existing defects, the information available to aid in the study of such a problem to-day is vastly better than could have been obtained a dozen years ago. The vital statistics are better, and the laboratory examinations of the water are vastly better than could possibly have been obtained at that time.

This investigation of Mr. Baker's, I think, is but a typical case of many such investigations that are going to be made to determine the effect of less grossly polluted waters upon the public health. The methods of investigation are improving as time goes on, and by proper use of them it is possible to follow the relation between water supply and disease further down the line and carry it to degrees of pollution the effects of which were at first too small to be observed or studied; and such investigations will extend our knowledge of the subject and will allow better and more reasonable discussions of the pollutions of water supplies, and the reasonable standards to be maintained in protecting waters from such pollutions, and in applying corrective measures where the pollutions themselves cannot be suppressed.

In discussing Mr. Crandall's paper, presented to this association in September, 1895, I ventured the statement that ten million dollars was not an overestimate of the loss in Chicago in one year, due to the polluted condition of the public water supply. This was based on typhoid statistics alone. Since that time I have become convinced that typhoid fever, as Professor Sedgwick suggested at the time, and as Mr. Baker now confirms, is wholly inadequate to measure the extent of damage caused by a polluted water supply, and the figure then given for Chicago was probably far below the real damage which resulted to the citizens of that city from the condition of the public water supply; and the loss was so great that it would amply justify almost any measures which might be necessary for the correction of the difficulty.

In the case of Burlington the amount of sickness and death which can be attributed to the water supply is small in proportion, but still, when carefully followed out and estimated, and reduced as well as it can be to a financial basis, it may be, and very likely is, far more than enough to justify whatever expense may be necessary in changing or improving the supply, as for instance, by filtration, as Mr. Baker recommends.

The day is rapidly passing when cities can continue to exist and prosper while killing their citizens by impure water. Already it makes a great difference with the prosperity of a city whether its water supply is healthful or not. It will not be many years before intelligent people will refuse to live in a city where they are subject to such dangers. The question is no longer whether or not it is worth while to furnish good water. It is getting to be whether a city shall continue to exist; for I believe the day is at hand when a city cannot exist in any adequate and satisfactory sense without a reasonably pure and wholesome public water supply.

MR. G. W. FULLER.* Mr. Baker's paper is an excellent one, suggesting broader and more reliable lines for water-works people to consider in dealing with the quality of public water supplies. The writer is heartily in sympathy with the studying of diarrheal diseases and their relation to drinking water. There is no doubt about polluted waters materially affecting general death-rates in this manner. Changes from polluted to relatively pure waters cause a marked reduction, not only in typhoid fever, but also in the general death-rate, principally through the influence upon the latter of deaths from diarrheal diseases. For some time there has been a growing feeling among sanitarians that this subject should receive more attention, and Mr. Baker is to be congratulated on his careful, painstaking data regarding the Burlington evidence.

The compilation of such statistics to show their influence upon the quality of public water supplies is not entirely new. In fact, it is understood that quite similar statistics were prepared under the direction of Mr. Rudolph Hering relative to the public water supply of Louisville, Ky., in 1892. Mr. Baker's paper shows, of course, in a striking manner the importance of having death certificates properly prepared, both as regards the diagnosis of the diseases producing death and their classification for accurate and ready reference in municipal records. In some ways the Burlington situation as to vital statistics is unusually free from complications as to other drinking waters than the public supply, although it is not free from questions of other general sources of infection, as mentioned by Mr. Baker in his paper.

Experiences of communities in discharging sewage into, and taking their water supply from, the same body of water are always interesting. Seldom has this proposition been faced with satisfactory results, although there are some instances where, under special conditions, this seems to have been true. The general question of the pollution of large bodies of water by sewage at points some distance removed from the point of sewage discharge is, of course, of growing importance to the sanitarians. To the writer it is particularly so as it bears indirectly upon the questions of foreshore pollution and the effect of sewage upon the shellfish industry. Views upon these matters are not so definite as they should be, and all carefully compiled data bearing upon the subject are of importance in getting views crystallized upon reliable and definite lines.

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* Civil Engineer, New York, N. Y.

By those who have had to do with water supply matters for cities on the great lakes it will be noted at once that the Burlington intake, although three miles removed from the principal outfall sewer, is in water of a depth of only 30 feet, and that the intake is turned upward until it reaches within 14 feet of ordinary low water. In this respect the Burlington supply differs materially from those of a number of cities having relatively good water from the great lakes. Reference is made to the fact that the lake water near the Burlington intake is so shallow that sediment, some of it presumably of sewage origin, is stirred up during heavy winds, and further that the supply is not protected by stratification from pollution by intermingling with the upper water. As to the effect of wind disturbances, it may be said that experience shows that severe storms may disturb large bodies of water to a depth of some 35 feet below the mean level. Stratification is of great importance, for instance at Milwaukee, where the water is drawn from Lake Michigan at a depth of some 80 or 90 feet, from a point where the bottom water remains at about maximum density very near all the time. In this way, although sewage may, perhaps, at times be driven by currents to the vicinity of the intake, the upper water, of lighter specific gravity and, perhaps, of doubtful quality, does not reach the intake. The latter is polluted, if at all, only by those bacteria which by chance settle from the upper water to the intake. The influence of this is presumably no greater than that of the residual bacteria in the effluent of a well-managed filter plant.

Several years ago the writer had occasion to investigate this matter at places both on Lake Erie and Lake Ontario. In the former lake it is probable that stratification hardly takes place to a degree to give much assistance in securing a good source of water supply. But in Lake Ontario, in the vicinity of Oswego, it was found that at a depth of 80 feet the water remains stratified with the exception of short intervals in the spring and fall, when there was an overturning from top to bottom. While stratification existed, the water at the bottom, with a lower temperature and higher density, showed no measurable effect of pollution even when winds and currents drove some of the harbor water along the surface to the vicinity of the proposed intake. Should such wind and current conditions prevail during the comparatively short period of overturning in the spring and fall, when stratification is absent, such protection could not be counted upon. With water from such a source supplied without filtration, it becomes desirable, and in some cases necessary, to be prepared to draw water from storage during conditions favoring the passage of polluted water to the vicinity of the intake.

Another point of some interest in this connection was encountered in a study of the water supply of Buffalo and suburbs, viz.: That winds generally produce an undercurrent moving in the opposite direction to that from which the wind blows. In this way, pollution, either through surface or undercurrents, may be carried probably to a greater distance than is generally appreciated.

Pollution of water supplies does not have to occur every day in the year in order to produce serious trouble. While it is important to settle the question, as Mr. Baker suggests, of whether there is a leak in the intake of the Burlington supply in order to show the effect of an unfiltered water supply from the present intake upon the consumers, it is not unlikely that during a few days in the year the water from the intake itself, due to conditions of wind and weather, is much below normal quality.

In the opinion of the writer the tests by so-called presumption methods for the presence of fecal bacteria in water require great caution in interpreting results.

DR. GEORGE A. SOPER.* It is unusual to find a paper upon the effects of impure water which has been so carefully prepared as the one under discussion. It is one of the most thorough and painstaking studies which have appeared, and the city of Burlington, no less than the members of this association, should feel indebted to Mr. Baker and those whose labors have contributed to this work.

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* Consulting Sanitary Engineer, New York City.

The single point which I desire to refer to in discussing the paper has to do with the amount of sickness which can fairly be attributed to the water. Should we go beyond the statistics of typhoid fever in estimating the extent of the connection between a water supply and disease? and if so, how far? In other words, what forms of illness may be communicated by such a water supply as that of Burlington, and how can the fact of the connection of these diseases with the water supply be established?

In the present state of our knowledge, it seems desirable to restrict our view of the possible consequences of drinking sewage-polluted water to diseases of the bowels; not that the impurities in such water may not, in some cases, cause other disorders, but because the chances of their doing so are too remote for practical consideration.

Probably the most important and difficult disease to investigate in connection with a water supply is typhoid fever. Because of the many forms which typhoid may take and the existence of popular delusions concerning it, it is doubtful if the extent of this disease is ever known with accuracy.

In investigating the cause and extent of existing outbreaks of typhoid fever, it has been my custom for years to study not only the cases of sickness which were readily recognized to be typhoid, but also those forms of illness which, by any chance, might be typhoidal in nature. I have generally included in this list cases reported as paratyphoid, paracolon, enteric fever, fall fever, dysentery, enteritis, diarrhea, and malaria. Recently I have added pneumonia, bronchitis, and tuberculosis, for I have not infrequently found genuine typhoid treated by physicians as these diseases. All such cases have been regarded in my investigations as of a doubtful or unsettled character until a special study of them could be made to ascertain with positiveness their real nature. Even with these precautions, it has been impossible to detect every case of typhoid. Exceedingly mild cases are often not reported by physicians at all. Sometimes erroneous or fanciful names are deliberately given to typhoid with the object of hiding the nature of the disease.

The kind of study made necessary by such an investigation requires the services of a number of trained assistants and the use of a laboratory for examining blood and other pathological and sanitary work. But these adjuncts are what should be available in investigations of epidemic diseases wherever an attempt is made to carry them on thoroughly, and I have generally found it practical to obtain all the facilities needed. This was so at Ithaca, N. Y.; Watertown, N. Y.; Williamstown, Mass.; Lawrence, N. Y.; and elsewhere. My chief difficulty has been in obtaining competent assistants.

In inquiring into the past records of disease no such satisfactory measures can be used to determine the exact number of typhoid cases. It may always be assumed that the number has been larger than that reported, but the ratio between the real number and the number indicated in the health records is never ascertainable. Cities which have the most typhoid are apt to be the most indifferent to it; their records, also, are likely to be the most inaccurate.

Mr. Baker has presented in his paper records of diarrheal diseases beside typhoid; not, apparently, with the idea that many of these cases were perhaps genuine typhoid, but because it seemed fair to suppose that many of them had been produced by the water supply. This appears to me to be a natural conclusion. Conditions which result in the contamination of a water supply with the germs of typhoid are also likely to lead to its pollution with the germs of other diseases. It is probable that a water supply is sometimes infested with the germs of several intestinal diseases at the same time. This is, I think, sufficiently indicated by the fact that in any large typhoid epidemic, various other diarrheal diseases, which are not typhoid, are apt to be met with. The diseases produced depend upon the nature of the micro-organisms contained in the filth which defiles the water. At Ithaca there were several annual visitations of diarrheal diseases before the extensive epidemic of 1903; during the progress of that epidemic several diarrheal diseases other than typhoid occurred and were believed to have been caused by the water. The typhoid epidemic at Watertown, N. Y., in 1904, was preceded by an epidemic wave of diarrhea.

Yet I am inclined to believe that records of other diarrheal diseases beside typhoid should be used with caution. So many other conditions may account for these disorders that it seems unsafe to ascribe an undue excess of them to water unless the other factors which enter into their etiology have been eliminated after careful study. The industrial conditions which prevail in a city may have a marked effect upon the infant mortality, and infant mortality usually represents the major part of diarrheal diseases not typhoid. The nationality of the population and their degree of intelligence and education are important factors in the matter. Above all, the condition of the milk supplies, the spring water supplies, the severity of the weather, the clean or dirty condition of the city and the housing of the laboring classes are conditions which should be taken very carefully into account before drawing any conclusions as to the cause of an undue prevalence of diarrheal diseases. In investigating these questions, whether they relate to present or past conditions, the coöperation and assistance of local physicians can sometimes be used to advantage, for although they are often poorly informed in matters of hygiene and the more scientific aspects of the causes of disease, their opportunities for observation are unrivaled and they are sometimes well informed.

Among the manifest difficulties to be met with in investigating the past records of diarrheal diseases in a city are those which rise from the fact that the conditions which should be studied in order to properly interpret the statistics are matters of history, often imperfectly recorded, and no longer subject to minute investigation. The making and interpretation of vital statistics is subject to more error than almost any other form of statistical work.

It is well known to the members of this association that what appears to be one of the most remarkable results of introducing a supply of pure water into a city whose water supply has previously been impure is a seeming reduction in the occurrence of diseases whose causes have no conceivable connection with drinking water. The statistics sometimes make it appear that the number of cases of practically all forms of disease has been reduced. If we were to credit the records and believe this theory, it would be necessary also to believe that its converse was true,— that the amount of sickness and death from all forms of disease was increased by impure water. If this opinion was held, it would be necessary in such a study as this one of Mr. Baker's to take account of every case and death known to the health authorities. I am far from saying that this would be an undesirable proceeding, but I do not think it would be warranted on the ground that the theory just alluded to was correct.

In fact I doubt whether it is true that the introduction of a pure water supply reduces the general death-rate as much as appears. It seems possible that often as much of a change takes place in the methods of keeping the records and interpreting them as in the health of the people, excepting so far as enteric diseases are concerned, and even here the beneficial results may be unintentionally exaggerated. In the sanitary awakening which a city experiences when a pure water supply is introduced, the condition of the public health and the work of the health office assume an importance and receive an amount of attention which they have never before known. From a position of comparative obscurity and neglect, the business of the board of health emerges into one of great prominence and responsibility. Everybody looks to the board to mark with official precision the extent of the improvement. Those persons who have to do with the records naturally share in this interest and desire that the city shall have as clean a bill of health as practicable. The report of each case of sickness and death is scrutinized with extreme care. Physicians are on their mettle. As few cases and as few deaths are charged against the city as is legally possible. Not seldom the sickness and death of persons from outside of the city who are taken ill within the limits, or are brought there for treatment, are recorded, after the installation of the new water supply, as having occurred in the places where the deceased claimed residence. In these ways the vital statistics are sometimes influenced without any intention on the part of any one to deceive.

When it is appreciated that cases of the commonest diseases due to impure water supplies often differ so markedly in appearance that physicians make mistakes in diagnosing them, that boards of health are often lax in keeping the records, that many other factors than the water supply contribute to the spread of what are known as water-borne diseases, and that the time and skill necessary to investigate the facts are seldom available, the value of such a long and careful study as Mr. Baker has made becomes evident.

Condensing my views on the subject to a simple and brief form, I should say that in studying the possible relation between a water supply and the health of a city, it is desirable to take account not only of the occurrence of typhoid, but of practically every other form of disease which occurs in the vicinity. The official records should be used more as clews to the truth than as evidence which needs no verification. Wherever possible, the investigation should call to its aid modern methods of pathological study. The value of the investigation will usually depend not only upon the official records or other information which may have been already collected, but also upon the skill and thoroughness with which the information thus offered is studied, checked, amplified, and interpreted.

The investigation of the Burlington situation has been fortunate in some respects. The statistical records seem to have been remarkably full and reliable, and the situation has been studied with a degree of thoroughness, competency and impartiality which, up to this time, has been very unusual. In the future, sanitary investigations of a far more exacting character than we have been accustomed to will have to be made. It is a vast mistake to suppose that only those sanitary matters need investigation and correction which are conspicuously dangerous. The investigation and correction of the more subtle and obscure causes of disease are at least of equal importance.

Dr. John S. Fulton.* The statistical exhibit which Mr. Baker has made of certain causes of death in Burlington between 1879 and 1905, and the arguments which he makes for a more liberal use of mortality data in determining the sanitary quality of the public water supply, seem to me most interesting. It is not surprising that Mr. Baker should have overlooked an important source of fallacy which affects all vital statistics, since the source to which I refer lies wholly in the domain of medicine, and is but little known outside the medical profession. It is difficult to bring medical men to realize the unreliability of the data which they themselves supply. All mortality statistics are based on the death certificate, and non-medical statisticians generally regard the death certificate as of fixed interpretation. As a matter of fact, however, medical men seldom write a death certificate with any appreciation of its utility as a contribution to vital statistics.

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* Secretary, State Board of Health, Baltimore, Md.

Its use as a basis for a burial permit is the only significance of a death certificate to a physician who is writing such a certificate. When these small documents in large numbers come up for statistical treatment their proper statistical reference is sometimes very difficult to determine. Not one physician in a thousand knows or cares anything about the nomenclature employed for statistical purposes. These nomenclatures themselves have their faults, and the very best that medical statisticians can do in these days is to move toward some sort of uniformity.

Too often the mortality data of American cities are made over into statistical tables by inexpert persons who are quite incompetent to translate the phraseology of a certifying physician into the rigid nomenclature of a statistical classification. In some items the terms of the classifications are vague, and very often the phraseology of a physician is vague. There is hardly any class of causes of death which admit so great a variety of vague terms as those diseases which are known as diarrheal diseases.

I suppose the term *typhoid fever* represents to the average layman a very definite cause of death. This term in pathology assuredly has a definite significance, but in clinical medicine the term "typhoid fever" in American practice does not occur in more than 60 per cent. of the certificates recording deaths which are really due to typhoid fever. At the present moment 40 per cent. of the cases of typhoid fever either wholly escape the diagnosis of attending physicians, or else, when death occurs, are recorded under some more or less vague name. If we trace typhoid fever back in the statistics we will find that the percentage of error increases the farther back we go, and for twenty-five years backward we find some twenty-five or thirty more or less confusing phrases employed by physicians to indicate deaths which, in all probability, were due to typhoid fever. Medical statisticians have but gradually come to understand this. A note in the first of Mr. Baker's tables says that the Burlington statistician has wisely added to the typhoid deaths the deaths reported as " bilious," " continued," " enteric," " slow," " typho-malarial " fevers. A similar note under Table No. 4 makes a similar exhibit and shows besides that the use of these unmeaning terms was far more prevalent formerly than now, although the absurd term " bilious fever " appears in Burlington's statistics as late as 1901. The terms *enteritis* and *gastro-enteritis* signify, for the most part, the medical man's confusion in the matter of diagnosis, though the statistician may have included in the *enteritis* column a certain number of deaths whose certificates did not bear the word *enteritis.* More than half of the deaths recorded under these two heads ought to be added to the typhoid fever column. If the deaths under five years of age, which have been ascribed to these two causes, could be taken away, 80 per cent. of the remainder could be added to the typhoid fever column without in the least overstating the truth about typhoid fever in Burlington between the years 1879 and 1905. One notes that the enteritis column includes here and there a death from *intestinal colic.* Intestinal colic probably means appendicitis, and the error of diagnosis in appendicitis also increases the further back one goes in the history of mortality. The *colitis* column includes certificates ascribing death to entero-colitis. A majority of these cases (enteritis, gastro-enteritis, entero-colitis, colitis), nearly all of those which were characterized by diarrhea, a duration of two weeks or longer, and ages above five years, should be added to the typhoid fever column. The remainder should be added to the dysentery column, and the small group of cases under the head of ulceration of the bowels should also be added to the dysentery column. The cholera morbus cases, which are few in number, have probably no relation whatever either to typhoid fever or to the water supply. Deaths classified under the heading cholera infantum probably include very few, if any, cases of typhoid fever, and these bear, in all probability, no considerable relation to the public water supply of Burlington. It will be seen, therefore, that a medical man's views bring him into substantial agreement with Mr. Baker's contention that, besides typhoid fever, several other columns of current mortality ought to be consulted in determining the sanitary quality of a public water supply. It would not be necessary, however, to consult half a dozen different items of mortality, if medical men were firmly convinced of the truth that typhoid fever is the commonest continued fever met with in the United States; for if this knowledge were faithfully reflected in the death certificates, such vague statistical terms as enteritis, gastro-enteritis, enterocolitis, would become emaciated almost to extinction. It will thus be seen that I can agree heartily with the main contention of Mr. Baker's paper and still believe that typhoid fever (frank typhoid fever plus disguised typhoid fever) will still remain the best, and almost sufficient, index of the sanitary quality of a public water supply.

MR. BAKER (*by letter*). I first wish to express my pleasure with the amount and character of the oral and written discussion, and with the fact that the paper has been received and considered as an attempt to present, in a rather tentative manner, some of the broader relations between water supply and disease than can be brought out by typhoid statistics alone. I also wish to say at the outset that some of the vital statistics presented in the paper were included for the purpose of throwing light on the deficiencies in the typhoid statistics rather than because they bear any well-defined relation to the character of the Burlington water supply. In fact, it seems more and more evident to the author that other sanitary conditions at Burlington are in almost as much need of investigation and improvement as is the water supply.

The author is particularly grateful to Messrs. Stone and Moat for their additional data on conditions at Burlington, Winooski, and Fort Ethan Allen. Had these data been in his possession before the paper was written he would have given more weight to the effect on the Burlington water supply of the pollution brought down by the Winooski River. Nevertheless, until further evidence is produced it can hardly be disputed that even if all pollution were removed from the Winooski River, the Burlington sewer alone would render the water supply so dangerous at times as to make its use without thorough purification unwise. This, it should be said, Messrs. Stone and Moat would doubtless be the first to admit. The author agrees with Dr. Stone that the study of leakage in the water intake is an engineering rather than an analytical problem; or perhaps demands the aid of both methods. Seemingly, it would be a simple matter to test the intake for leakage, and no further time should be lost before doing so. The need of better records of vital statistics at Winooski and more thorough investigations of all reported cases of communicable disease at both Winooski and Burlington is evident. Every reported case of typhoid fever in the two municipalities and at the Fort should be looked into most carefully for the purpose of showing both its origin and its possible or probable effect upon the Burlington water supply. If this were done, and if careful analytical tests of river, lake, and city water were made at frequent intervals, and if at the same time both cases and deaths of diarrheal diseases were systematically studied, much additional light might be thrown on water supply and disease at Burlington and elsewhere. Much of this work properly belongs to the several local authorities, but in carrying it out there might well be coöperation between them and the State Laboratory of Hygiene.

Mr. Leighton is peculiarly qualified to discuss the paper, on account of the studies of the pollution of Lake Champlain already mentioned. His belief that within the past few years typhoid fever has been fully reported at Burlington is in part supported by all the evidence before us, but only in part. That there has been improvement there can be no doubt, but the continued high diarrheal mortality indicates faulty nomenclature, to say the least. This indication is supported by the excess of positive Widal reaction tests, as given by Dr. Stone, over reported typhoid cases, unless the Widal reports include duplicate tests. In 1905, in particular, the positive Widal tests numbered 77, against 32 reported cases of typhoid fever. It is gratifying to note, however, that the Burlington physicians seem to be trying to learn the truth, for in 1905 there were 113 negative as well as 77 positive Widal tests. It may be noted that Mr. Leighton, contrary

TABLE No. 12.—TABLE DESIGNED TO SHOW EFFECT OF ICE OVER LAKE CHAMPLAIN ON TYPHOID MORTALITY AT BURLINGTON, VT.

	Broad Lake.		Days	Typhoid Deaths.	
	Closed.	Opened.	Closed.	Jan.-Mar.	Year.
1890	February 10, 21 March 7	February 11, 28 March 12	13	2	4
1891	January 27 February 14 March 8	January 31 February 27 April 2	42	3	4
1892	February 14	April 3	49	2	7
1893	January 16	April 12	86	7	10
1894	February 6, 12	February 10 March 15	35	1	2
1895	February 7	April 19	71	0	1
1896	February 17	April 17	60	1	4
1897	January 31	April 10	69	0	2
1898	January 30	March 16	45	3	5
1899	February 1	April 20	78	1	2
1900	February 28	April 19	50	4	7
1901	February 1	April 11	69	3	5
1902	January 30	March 28	57	0	2
1903	January 24 February 19	January 30 March 12	27	0	3
1904	January 19	April 13	85	1	7
1905	January 23	April 13	80	2	3
	Total Deaths	(average closure)	57	30	68

The bay at Burlington and also the Winooski River would be covered with ice when the "broad lake," which is here some ten miles wide, is not frozen from shore to shore. Earlier statements regarding lake closure are not available. The observations given were recorded by Mr. Charles Allen, of Burlington, Vt.

to Dr. Stone, suggests bacterial tests to ascertain the tightness of the intake. Mr. Leighton's remark to the effect that the monthly distribution of typhoid (Table No. 4) shows that the disease is at its worst when the lake is covered with ice (or really in the months when such a covering would be expected) leads me to include a table (Table No. 12) compiled from the city reports of Burlington, showing for the past sixteen years the dates on which the "broad lake" closed and opened opposite Burlington, the days closed each winter and the number of typhoid deaths for the January–March quarters of the corresponding years, and the total numbers of typhoid deaths for the several years.

While the figures in detail do not show as much connection as might be expected between a disproportionate amount of typhoid in the first quarter of the year and a long period of ice closure of the lake, yet it may be noted that, in 1893, the worst typhoid year indicated by the table, 7 of the 10 typhoid deaths occurred in the first quarter, and in that year the lake closed earlier and remained closed longer than any other year of the sixteen. The following winter was an open one, and in August (1894) the water intake extension was put in use. Only two typhoid deaths were recorded, one of which was in the first quarter. In 1895, the lake was closed seventy-one days, but there was only one typhoid death, and that in the later part of the year. The effect of the new intake was shown in this and a number of subsequent years, but beginning with 1900, typhoid again rose. With the exception of 1900 and 1904, typhoid has been highest when the lake was closed longest, and in three of the six years more than half of the typhoid deaths have been in the first quarter of the year. It should be noted that the bay and river, the region of sewage influence, are closed earlier and longer than the broad lake, and that the table inserted in this discussion shows that for the whole sixteen years 30 of the 68 typhoid deaths recorded were in the first quarter of the year when they would be least expected, pointing undoubtedly to the protective effect of ice covering on the typhoid germs in the lake water. With the recurrence of typhoid from 1900 on, only 10 of the 27 recorded typhoid deaths were in the January-March quarter, indicating that the typhoid infection, from whatever source, is becoming more generally distributed throughout the year.

Mr. Weston suggests that hospitals in general have little effect, that need be considered, on the vital statistics of cities. This may be true for large cities, for, as Mr. Weston says, the out-of-town patents who die in such hospitals may be balanced by the people of those cities who die elsewhere. But in a city like Burlington, with no hospital in near-by places, the out-of-town patients are less likely to be balanced in such a way. Dr. Stone also states as his belief that the hospital at Burlington has little effect on the number of typhoid deaths, since the taking of typhoid cases is avoided there. Probably the Burlington hospital does have but little effect on typhoid in Burlington, but doubtless it accounts in part for the high general mortality in that city. The two childrens' homes, taking children from without the city, add to the under-five population, and therefore contribute to the unduly high infant mortality.

It is to be regretted that the Louisville figures mentioned by Mr. Fuller could not be included in the discussion. The author is informed that Mr. George C. Whipple has also collected some diarrheal statistics in connection with water supply studies at Cleveland, Ohio. Mr. Fuller's remarks on the need of caution in interpreting results obtained with presumptive methods for determining fecal bacteria deserve attention in connection with the large number of colon bacilli reported as found at Burlington.

Dr. Soper's remarks, like those by Mr. Hazen and others, endorse the author's general idea of broadening the scope of the vital statistics commonly used in studying the effects of water supplies on the public health. Dr. Soper would go even further afield, taking in other than diarrheal diseases, not because these are caused by bad water, but because, for one reason or another, they cover up many typhoid cases and deaths. The author agrees with Dr. Soper that the diarrheal statistics should be used with caution and that a variety of other factors than the water supply should be considered in studying diarrheal mortality. It is particularly desirable that this should be done at Burlington, where, as the author pointed out in his report to that city in 1905, the sanitary condition of the milk supply has received very little attention as yet, and where housing conditions and infant feeding, among a considerable part of the population, are probably bad.

The association and the author have reason to be thankful for the discussion contributed by so eminent a vital statistician as Dr. Fulton. It is only fair to the health officials of Burlington for the author to take upon himself the full responsibility, as he thought he made plain in the paper, for searching out in the twenty-six annual reports and grouping together by years and classes all the statistics included in the tables, and for making the reclassifications indicated by footnotes. In no one of the Burlington reports is there a comparative study of any of these mortality figures by years, nor did any of the health officers, so far as the reports show, ever reclassify as typhoid fever a death reported by a physician as "bilious" fever, "continued" fever, etc. In the same year the mortality reports include deaths from typhoid fever and enteric fever as though the two diseases were not identical. The later reports bear circumstantial evidence, but no direct proof, that some reclassifications have been made by the health officer. Probably, however, the disappearance of "bilious" fever and the like from the mortality tables is largely due to improvement in the nomenclature used by the practicing physicians.

Finally, the author expresses a hope that other attempts will be made to broaden the studies of the relations between typhoid and the public health; that health officers and practicing physicians will devote themselves far more earnestly and intelligently than heretofore to the perfection of vital statistics, both in completeness and in classification; and that the city of Burlington will soon find some permanent means of improving the character of its water supply and, what is, perhaps, even more important, of introducing other sanitary reforms, all of which combined will result in the reduction of its typhoid, diarrheal, infantile, and total mortality to a figure appropriate for a city of its unsurpassed natural conditions.

PROCEEDINGS.

MARCH MEETING.

HOTEL BRUNSWICK,
BOSTON, March 14, 1906.

The President, Prof. W. T. Sedgwick, in the chair.

The following members and guests were in attendance:

MEMBERS.

M. N. Baker, C. H. Baldwin, L. M. Bancroft, W. T. Barnes, G. W. Batchelder, J. E. Beals, E. M. Blake, George Bowers, E. C. Brooks, G. A. P. Bucknam, J. C. Chase, R. C. P. Coggeshall, M. F. Collins, E. R. Dyer, H. P. Eddy, E. D. Eldredge, I. T. Farnham, J. N. Ferguson, Desmond FitzGerald, F. F. Forbes, D. W. French, T. C. Gleason, A. S. Glover, F. W. Gow, J. O. Hall, J. C. Hammond, Jr., L. M. Hastings, V. C. Hastings, H. G. Holden, J. L. Howard, E. W. Kent, Willard Kent, L. P. Kinnicutt, H. V. Macksey, D. E. Makepeace, A. D. Marble, A. E. Martin, W. E. Maybury, John Mayo, A. S. Merrill, F. E. Merrill, H. A. Miller, C. A. Mixer, Wm. Naylor, G. H. Palmer, W. W. Robertson, C. M. Saville, E. M. Shedd, C. W. Sherman, Sidney Smith, G. H. Snell, G. A. Stacy, J. T. Stevens, R. J. Thomas, H. L. Thomas, W. H. Thomas, W. H. Vaughn, R. S. Weston, J. C. Whitney, O. J. Whitney, I. S. Wood, C.-E. A. Winslow, G. E. Winslow, E. T. Wiswall. — 64.

HONORARY MEMBERS.

W. T. Sedgwick, F. W. Shepperd. — 2.

ASSOCIATES.

Builders Iron Foundry, by F. N. Connet; Chapman Valve Mfg. Co., by Edw. F. Hughes; The Fairbanks Co., by F. A. Leavitt; Hersey Mfg. Co., by Albert S. Glover, Jas. A. Tilden, H. D. Winton, H. V. Macksey; International Steam Pump Co., by Samuel Harrison; Macleod & Co., by W. F. Stoddard; Ludlow Valve Mfg. Co., by H. F. Gould; H. Mueller Mfg. Co., by G. A. Caldwell; National Lead Co., by G. L. Whittemore and H. McConaghy; National Meter Co., by C. H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey and F. W. Hawks; Rensselaer Mfg. Co., by F. S. Bates and C. L. Brown; A. P. Smith Mfg. Co., by F. N. Whitcomb; Thomson Meter Co., by Edward M. Shedd; Union Water Meter Co., by W. F. Hogan; United States Cast Iron Pipe & Foundry Co., by F. W. Nevins; R. D. Wood & Co., by Wm. F. Woodburn. — 24.

GUESTS.

Hon. Thomas Thompson, Mayor, New Bedford, Mass.; T. H. Dearing, M.D., Water Commissioner, Henry A. Monk, Clerk, and John Kelly, Water Commissioner, Braintree, Mass.; Clarence Goldsmith, Supt., North Andover, Mass.; C. W. Gilbert, Woburn, Mass.; R. R. Thomas, Quincy, Mass.; F. L. Clapp, Stoughton, Mass.; A. H. French, Brookline, Mass.; G. A. Sampson, Boston, Mass.; C. Story, H. M. McRae, G. H. Bryant, G. H. Hanley, G. E. Washburn; C. H. Rollins, Water Commissioner, Watertown, Mass. — 16.

[Names counted twice. — 4.]

After the dinner had been served, President Sedgwick called the company to order, and said:

"Death has invaded our membership since the last meeting and taken from us one of our vice-presidents, Mr. Frank A. Andrews, of Nashua, N. H.; and another member, Mr. T. W. Mann, of Holyoke, has also died. These events remind us that the association is always losing at one end and needs always to be gaining at the other; in other words, we must ever be on the lookout for new members to take the places of those who pass away. This association can do its best work only if it has a large and vigorous membership, provided, of course, that that membership is of the right quality. In the Executive Committee meeting to-day we have been discussing the advisability of adding steadily new and fit material to our membership. Let each one of us see to it that no man who ought to be a member goes on long without being proposed for membership The Executive Committee will be glad at any time to receive applications.

"The next meeting of the association will be the annual field-day meeting. For this plans are not yet fully matured, and the Executive Committee would be pleased if any members who have bright ideas as to proper 'stunts' to carry out on field day would communicate those ideas to the committee. In other words, the Executive Committee will welcome hints from all sources, — although they will not promise to adopt any of them.

"The first business in order is the election of new members, and I will ask the Secretary to read the names of candidates who have been passed and approved to-day by the Executive Committee."

The Secretary read the names of the following applicants for membership:

Ransom Rowe, Lynnfield, Mass., Water-Works Contractor; James A. Tilden, Hyde Park, Mass., Mechanical Engineer; George G. Honness, Katonah, West Chester County, N. Y., with the New York City Aqueduct Commission; Dabney H. Maury, Peoria, Ill., Consulting Engineer; Nicholas P. Simin, Moscow, Russia, Chief Engineer, Moscow Water Works; Francis F. Longley, Washington, D. C., engaged in water supply, water purification, and other engineering work.

On motion of Mr. Bancroft, the Secretary was directed to cast the ballot of the association in favor of the applicants, and they were declared elected.

THE PRESIDENT. Massachusetts is a state of cities, and among the cities that adorn the state and, as we believe, adorn New England, there are few more thriving or more prosperous than New Bedford. We are fortunate in having as one of our guests to-day the chief magistrate of that city, Mayor Thompson, who has kindly consented to say a word to us as members of the New England Water Works Association. I have great pleasure in presenting Mayor Thompson of New Bedford.

Mayor Thompson was received with hearty applause, and in response said:

Mr. Chairman and Gentlemen, — It is a pleasure for me to be here before such an intellectual body of men, especially as all are designated as being on the water wagon. [Laughter.]

New Bedford is a thriving city, and no doubt every one of you has read of some of the conditions which are surrounding the municipality of New Bedford. There are peculiarities that surround every municipality, and New Bedford is no exception, although we pride ourselves on being the first city in this great country in what we call the manufacture of fine goods. We have 42 cotton factories in New Bedford, with a capital stock of about $15 829 000. The amount of dividends paid last year was $829 500, or about 5.94 per cent. upon the money invested.

There is one thing that we had to do, and that was to increase the water rates to the manufacturing interests in New Bedford. It shouldn't have been done, but as they desired to have the water department upon a paying basis they placed from two and one-half cents a thousand gallons up to fifteen, making an additional expense to the cotton factories and the various other manufactories in New Bedford of about $65 000.

We are trying to put meters in to the best of our ability, but some man up here in our legislature, who is more conversant with crazy quilts than he is with meter systems, is trying to compel all municipalities in Massachusetts to meter every service and and to attach a penalty if you don't do it before a certain date.

Now, I think we citizens of Massachusetts have, to a degree, lost faith in our representatives and our senate, simply because we don't go around and look after these freak bills that are being presented to the legislature by interested people.

There is no doubt of it, there has been a peculiar situation in New Bedford. We have a license commission. The license commissioners are appointed by the mayor and controlled by the mayor. The license commissioners do not grant the licenses; they vote for them, that is all, but the mayor selects those who shall have the licenses and the commissioners simply concur. And why? Simply because when it comes up to a question of an election they want to have those fellows, because you know there is more profit in whiskey than there is in molasses, because when business is poor they can put the hose into the barrel and forget to take it out, and so when they can't get a percentage over the counter in any other way they can make it on the water, for we only charge $2.50 for a faucet. [Laughter.] So you see that, he having the control of that department, it is very easy for him to say when it comes election time to one of these men, "I should like to have $500 from you for the campaign fund." He says, "I can't afford to pay it." Put the pencil through his name; he can't have a license. But he don't want to go back and work in a sewer; he don't want to use a pick.

They tell a story down in New Bedford about a fellow who was down on the wharf looking at one of the old whalers, and his attention was attracted by a big anchor which was lying there. He stayed round so long that finally somebody asked him what he was waiting for. He replied, "I am waiting to see the man who uses that big pick." [Laughter.] Now, these fellows don't want to go out and work with a pick or a shovel; they know there is more profit in the liquor business. They know they can make four or five thousand dollars a year, and for the chance to make it they are willing to pay that $500. The legislature of Massachusetts has placed that upon us by saying there shall be one license for every 1 000 people in a municipality, so New Bedford has about 74 licenses. And, of course, for years past we have been subjected to what you may call the pseudo-apothecary shop. It is patent medicines and Peruna alongside of nursing bottles and liver pads. Down cellar they make the goods and in the back shop they deliver up. [Laughter.]

And the municipality has been retrogressive along these lines and spending its money extravagantly, actually throwing it away; in the month of January, under the new overseers of the poor that I placed there, we saved $50 a day even in our poorhouse, and on the outside we saved $60 a day, making $110 a day, and without any real detriment to the municipality of New Bedford. But because of the former extravagance we were forced to saddle upon the manufacturers of the city of New Bedford $65 000, and then our water department receives the blame, because of the extravagance and the incompetency of the men who have handled the administration.

So I say to you men who are trying to give the people what will be beneficial to them, and to bring to the man bloom upon his cheek and not waste and take from the man or curb his physical or destroy his mental powers, that these men, who hold the reins of government through the power of liquor have simply subjected the water boards of Massachusetts to that condition of things, and it will happen in every municipality of Massachusetts, I care not which it is, unless we can arrest that condition that monopolizes man and makes him bow subservient to the selfish ambition of any man or any coterie of men. And if you men are alive to the situation of a progressive municipality you can take this thing in hand; and that is the paramount question to all other questions, because the water departments of this great state are proving to us the possibilities of municipal ownership in the near future, so that the car tracks and lighting and so forth shall come into the hands of the people in order that the people may have the revenues from what they consume and pay for. And if you men will only just clasp hands in one great chain from the Berkshire Hills to old Cape Cod, you can give Massachusetts better legislation by sending better men to the legislature, who will enact laws that shall be beneficial to the great body of the citizens of Massachusetts, so that posterity can walk in a narrow path and climb the mountains in the future because we have fought and have educated them to fight for the solution of the great and complex questions that confront us in this great and growing country of ours. Gentlemen, I thank you. [Applause.]

THE PRESIDENT. Mayor Thompson has touched on many points of interest to water-works men, certainly on one which we can all subscribe to, and that is that in our municipalities not infrequently water boards have suffered because of extravagance or ill-advised efforts in other municipal directions. What is greatly needed is some wise supervision of all municipal affairs, so that the schools and the streets, the water department and all other departments shall have their just and proper share of funds. We are grateful to you, Mr. Mayor, for bringing up these points.

The principal paper of the day, gentlemen, will be by one of our own members, the distinguished associate editor of an important engineering paper, the *Engineering News*, and a gentleman whose activities range over a wide field. Mr. Baker is not only an expert on water and water supply, but he is the president of one of the best boards of health in the United States, the board of health of Montclair, N. J. I know of my own knowledge that this board has been more progressive, more scientific, more courageous, and more successful than almost any other local board of health of any place of equal size in the United States; and I believe that to be so largely because it has had upon it good physicians, good citizens, and especially a good engineer in the person of Mr. Baker.

This association has always been interested in sanitary questions, particularly as affecting water supplies. Many of you who have been connected with it as long as I have, or longer, have seen great changes in our attitude and in the attitude of the public toward water supplies, and some of you have heard in the past about the conditions at Burlington, Vt. Mr. Baker is thoroughly familiar with the conditions there, and especially with the modern conditions, and I esteem it a great privilege that we are to hear from him this afternoon upon the water supply and certain sanitary matters connected with the water supply of Burlington.

It is a matter of regret that no representative, as far as I know, is present to-day from that city. We have members there, but Burlington is a long way off. We have had submitted, however, typewritten comments upon Mr. Baker's paper by some of the municipal authorities of Burlington, and also by some members of the association, especially Mr. Hazen of New York and Mr. Leighton of Washington. I will ask Mr. Baker to present his paper now, but we will postpone our discussion of it for a short time while we listen to a description of the pitometer, which has been set up here in the middle of the room, by Mr. Blake, and then we will have a discussion of Mr. Baker's paper and, if time permits, of Mr. Blake's. I have great pleasure in presenting Mr. Baker. [Applause.]

MR. M. N. BAKER. I wish to thank the President for the kind word which he has spoken of the Montclair Board of Health, because I am deeply interested in having the work of boards of health throughout the country entered upon with more vigor, and I therefore welcome every opportunity which calls attention to the efforts which we have made, in the hope that similar efforts may be made in other communities; for, I regret to say, to a large extent throughout the whole country the work of local boards of health is, considering the vital interests involved, in a very shameful condition indeed.

Mr. Baker then proceeded with the presentation of his paper, which was entitled " Water Supply, Typhoid Fever, and Diarrheal Diseases in Burlington, Vt., 1879 to 1905, Inclusive."

EDMUND M. BLAKE, civil engineer, of Boston, explained "The Pitometer and Its Uses "; after which there was a discussion of Mr. Baker's paper. First, a communication from Dr. B. H. Stone, director of the State Laboratory of Hygiene at Burlington, Vt., was read by Mr. Coggeshall. Mr. Robert S. Weston, Mr. C.-E. A. Winslow and Prof. Leonard P. Kinnicutt participated in the oral discussion which followed, and papers by Mr. Allen Hazen and Mr. M. O. Leighton were presented.

On motion of Mr. Bowers the meeting adjourned.

EXECUTIVE COMMITTEE.

TREMONT TEMPLE, March 14, 1906.

Present: President William T. Sedgwick, R. J. Thomas, F. W. Gow, F. E. Merrill, L. M. Bancroft, Charles W. Sherman, John C. Chase, Willard Kent.

Six applications for membership were received and approved, *viz.*, Ransom Rowe, George G. Honness, Dabney H. Maury, James A. Tilden, Nicholas P. Simin, and Francis Fielding Longley.

On motion of Mr. Sherman, seconded by Mr. Thomas, the following ruling was unanimously adopted: " That applications for admission as members may be received from persons otherwise eligible, engaged in a technical capacity with firms dealing in, or manufacturing, water-works supplies, provided the said firms are already Associates."

Voted: That the President, Mr. Stacy, and Mr. Merrill, be a committee on the June Field Day with full powers, including that of adding additional members.

Voted: That the above committee be also a committee on the Annual Convention.

Voted: That, as an experiment, the tabulation of water-works statistics be omitted from the JOURNAL for the present year, but published next year and thereafter biennially.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

OBITUARY.

Thomas W. Mann, civil engineer, of Holyoke, Mass., died in that city on February 28, 1906.

Mr. Mann was born in Ireland about sixty years ago and came to this country when ten years of age, with his parents, who settled in Holyoke. After graduating from the Holyoke High School he received an appointment to West Point, but failed to pass the physical examination. He then took up civil engineering, and for some years he was employed by the Holyoke Water Power Company; later he opened an office for himself, which he maintained for some twenty-five years. He was town engineer of Holyoke before it became a city, and was city engineer in 1884 and 1885.

He became a member of the New England Water Works Association on June 9, 1892.

Frank Albert Andrews, assistant superintendent of the Pennichuck Water Works, Nashua, N. H., and one of the vice-presidents of the New England Water Works Association, died on March 1, 1906.

Mr. Andrews was born in Nashua, August 3, 1865. He had been with the water company for twenty years, and had been assistant superintendent for several years.

In addition, he was a member of the insurance firm of Andrews, Son & Co., and was an officer of several corporations. A local paper says of him:

" Mr. Andrews was one of the sunniest of the active young men of the city. He was upright and in the open in all his business transactions, and in the social circles of those of his own age no man was more highly regarded as being unselfish and determined on doing all he could discover to do to add to the happiness of those with whom he was associated."

He was elected a member of the association on December 14, 1887.

JOHN JAMES ROBERTSON CROES, one of the most widely known civil and hydraulic engineers of this country, died March 17, 1906. Mr. Croes was a past president of the American Society of Civil Engineers, and an honorary member of the New England Water Works Association.

Mr. Croes was born in Richmond, Va., November 25, 1834. His early boyhood was passed in Terre Haute, Ind., and he was educated in the College of St. James, Hagerstown, Md., graduating in 1853. He then took up the study of civil engineering in the offices of practising engineers. He was employed on the Brooklyn Water Works, the New York Water Works, and the Washington Aqueduct; and then, after a short service under James P. Kirkwood on investigations relating to St. Louis and Cincinnati water works, returned, in 1865, to New York to take charge of surveys for storage reservoirs in the Croton valley. He was connected with the Croton Works for a number of years, and later with the New York Department of Parks. During the last twenty-five years he had been connected as chief engineer or consulting engineer with many important engineering enterprises.

Mr. Croes became a member of this association June 17, 1887, and on September 14, 1904, was made an honorary member.

BOOK NOTICE.

HYDRAULIC MOTORS. By Irving P. Church, M.C.E., Professor of Applied Mechanics and Hydraulics, Cornell University. New York: John Wiley & Sons. 1905. ix + 280 pages. 6 × 9 inches. Price, $2.00.

This excellent book has been prepared as a text-book to be used by students already well-grounded in the principles of mechanics and hydraulics. It is particularly adapted for use after Professor Church's "Mechanics of Engineering," to which it may be considered supplementary. Mathematics are used freely. Like all of Professor Church's writings, the reasoning is clear and logical, and the explanations are excellent.

The titles of the chapters are: Chapter I, General Considerations and Principal Types of Motors; Chapter II, Gravity Motors; Chapter III, Preliminary Theorems fundamental to the Theory of Turbines and Centrifugal Pumps; Chapter IV, Impulse Wheels; Chapter V, Turbines and Reaction Wheels; Chapter VI, Testing and Regulation of Turbines; Chapter VII, Centrifugal and "Turbine" Pumps; Chapter VIII, Pipes, Weirs, and Open Channels; Chapter IX, Pressure-Engine, Accumulators, and Hydraulic Rams; Appendix, Diagrams and Tables.

The several types of wheels are illustrated both diagrammatically and by views of actual wheels. Among the views are a number of excellent half-tone plates of some of the very large recent wheels.

NEW ENGLAND WATER WORKS ASSOCIATION.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

PROGRESS REPORT OF THE COMMITTEE ON METER RATES.

BY THE COMMITTEE.

[Presented September 14, 1906.]

The Committee on Meter Rates is gratified that the discussion upon its report* has been so general and so intelligent. The fact that its suggestions have been favorably criticised in some instances and unfavorably in others, shows that the conditions under which meters are installed vary to a great extent in different places, and the subject presents itself in different ways to different people.

In replying to some of the suggestions and criticisms brought out by its report upon meter rates, the committee does it in no spirit of antagonism to the suggestions or plans proposed. It seems desirable that all points should be discussed, and the advantages of any proposal, or the objections to its adoption, emphasized.

Mr. Herschel in his discussion of the matter suggests, or seems to suggest, that the part of the annual cost of a system of water works which is due to the provision of large capacity standing ready for service should be met by a charge for fire service, and that the balance be met by a charge for water actually used. This is an excellent suggestion, and is only another way of doing what the committee suggests, namely, meeting fixed charges by an assessment, or appropriation, which is independent of the amount of water used. The committee agrees with him that this should be paid out of the tax levy, and it furthermore believes that an equitable proportion of the entire annual maintenance expenses to be raised in this way would approximate one half. Unfortunately, however, the prevailing idea seems to be to keep this appropriation for the tax levy as small as possible, and, as the revenue from consumers increases, to eliminate it entirely, rather than to relieve the consumer by reducing the rates, as equity between consumer and taxpayer certainly demands. As practical men, we must advocate practical measures, and however desirable it is that there should be a more equitable arrangement between the consumer and taxpayer than now exists, the committee feels that it is more feasible in the present state of things for the department to take what can be had from the tax levy, as proposed by it, applying it to the payment of fixed charges, and raise the balance for meeting those charges by an assessment of some kind, than to endeavor to convert municipal governments to the idea of appropriating an adequate amount for fire protection. The taxpayer probably has greater influence with the city council than the consumer has.

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*Presented September 13, 1905, and published in the JOURNAL, September, 1905, p. 322.

After the charges for " standing ready " are met, the water furnished can be paid for upon the basis of the actual quantity used, as both Mr. Herschel and the committee agree. The committee, however, does not agree with Mr. Herschel " that to attain simplicity is reason enough to reject the committee's plan of front-foot assessment." It does not consider the front-foot plan as a complicated method, but, on the contrary, as a simple one, and the difficulty of adoption is not on account of its complexity, but on account of its newness, or because it is different from any method now in use. Mr. Herschel regrets that the committee— in saying, " If the first system (gravity system) has an ample supply, it costs no more (within certain limits) to furnish a large amount of water than a small one" —" gives renewed currency to an exploded fallacy." The statement of the committee is certainly a fact, and if, as Mr. Herschel says, it is an " exploded fallacy," it is, we presume, so much the worse for the fact. If the remainder of the committee's remarks upon this subject are examined, it will be seen that it draws no unwarrantable conclusions from the above guarded statement.

In regard to the question of favoritism to manufacturers, which Mr. Herschel raises, that is the very thing that the proposition of the committee avoids, or at least seeks to avoid. A sliding scale may or may not be favoritism, but a plan to make all consumers, or property owners, pay their proportional part (however it may be ascertained) of the charges due to " standing ready," and then pay a uniform sum per unit for water actually used, is as far removed from favoritism as any plan can well be. It is not specially in the interest of manufacturers that the plan is proposed, but in the interest of the water department, which will surely be benefited by a method of supplying water equitably to large and small consumers. It is undoubtedly to the advantage of the community as a whole that both domestic and business consumers should have all the water of which they can make a legitimate and profitable use, as well as that all waste should be stopped.

The committee has referred in its report to the difficulties in the way of adjustment of the revenue attendant in many places upon a strictly metered rate without a minimum charge of some kind, a subject which Mr. Herschel altogether ignores, *and one which must be considered.* He lays great stress upon the equitable method of charging, and says that to him there is but one simple way, — " to charge by the quantity used or wasted that is consumed on the premises." Is it equitable that a house that occupies a large lot of land, with plumbing fixtures for a luxurious use of water, and occupied by a small family, should pay a very small sum, simply because it uses little water, while the cost of the entire system is increased by the length and size of pipe and other elements of construction, necessary to " stand ready " to supply such a house? Is it not more equitable that a sum should be paid to meet the fixed charges on the construction, whether a large or small amount of water is used? On the other hand, if a house is on a small lot, and has but one faucet, why should not the sum for fixed charges be paid, and in addition a sum for a large amount of water (used only through one faucet and consequently at a slow rate and not requiring large street piping, etc.) at a rate representing the actual cost of collecting and delivering the water, exclusive of fixed charges? It may be said that this is a different method from that used in selling gas and electricity. This is true, but it does not differ more than the conditions. Fixed charges do not constitute so important an item in the latter cases. The cost of the plant is not so large in proportion to the value of the product. Labor and material enter into the cost of gas and electricity to a larger extent than into the cost of water, the actual cost of which is usually very small; the items of coal and salaries being almost the only items that vary with the amount of water used, assuming that the plant is of sufficient size. The size of the piping is dependent more upon the need of fire service than upon the consumption of water, especially in the smaller places.

Electric and gas companies do, however, often make a minimum charge. This charge in some places is one dollar per month, which must be paid if no lamp is lighted.

The committee feel that an insistence upon the principle that *all* charges for water must be strictly upon the amount *used* will do more to prevent the use of meters than any other one thing, and that a minimum, or a separate, rate to meet fixed charges is an absolute necessity of a meter system in most places.

Mr. Hazen put the argument of the committee in a very effective form in the early part of his discussion. The Cleveland plan, as described by Mr. Bemis, is practically the same as the committee's plan for a " multiple minimum " method, but worked out on a different basis than the Merrimac rates, which were given in the report as an example of the method in actual use, and which were designed about the time the Cleveland plan was adopted. The fact that the origins of these essentially similar plans were entirely independent suggests that there may be merit in this method for meeting certain prevailing conditions.

The committee, after carefully considering the discussion, is still of the opinion that it is in most cases absolutely necessary to have a minimum in some form, or to have a rate composed of two elements; one of which represents the fixed charges of the system, or the fair cost of " standing ready," and which must be paid independently of the amount of water used; and the other, for the water used or wasted.

It also feels that it is unessential upon what basis the rate for fixed charges is determined, so that it is independent of the *amount* of water used, and approximately represents the comparative benefit that is rendered to any particular piece of property. It may be, as suggested in the report, upon frontage, which seems a fair and available measure, or it may be upon the assessed value of the property.

The committee fully recognizes the unsatisfactory condition in which the fire service question stands in respect to the amount which shall be paid for it, and makes the following suggestion, which it believes could be adopted by either a municipality or private water company (except that vacant land and unserved houses could not be assessed by the latter), and that it would be an equitable and feasible solution of the question of the charge for fire protection.

Make no charge to the city, or appropriation from the tax levy, for fire protection, but collect from all property upon the pipe line (with the above exception) a sum representing the fixed charges of the system based upon the assessed value of the property as taken from the assessors' books. This sum may amount to approximately one half of the total annual expenses of the water works, including interest and sinking fund. The remainder of the annual expenses will be collected for the use of water, and strictly in accordance with the amount used. The result of this will be that all property on the pipe lines will pay for fire protection, as it should, and no property off the pipe lines will make any such payment. Vacant land and houses not taking water will pay in proportion to their value, as they should, for the benefit received on account of the existence of the line and the consequent enhanced value. It is probable that this class of property must be omitted from the assessment in the case of water companies.

This plan will provide that the cost of fire service be paid by property that is benefited; that the water shall be paid for in proportion to the *quantity used*; will allow, if desirable, that the unit price of water shall be uniform to large and small users; that an intelligent estimate of the relation of revenue to expense can be made, and that there will be no serious excess or deficit under the existing rates, and without making any increase in general taxation for city purposes. It will be practically the assessment method of the committee's report, except that it substitutes assessed values for frontage and eliminates the question of raising funds for fire purposes by the ordinary tax levy; it provides that property shall pay for the benefit it receives, and that consumers shall pay the cost of what they receive. It recognizes the fact that property owners and water consumers are not identical, and may or may not be the same persons; and the committee suggests it as an alternative method with some advantages that the frontage plan does not have. This method also meets a frequent and valid objection that is raised by that part of the population of towns outside of the district actually served by the water supply, namely, against being taxed for improvements in which they do not share. It would obviate the necessity of forming a fire district inside of the town itself, which has been done in so many instances in order to avoid the opposition of outside taxpayers to the installation of needed water supply systems.

As an example of the working of such a system, suppose a house with modern plumbing, paying under fixture rates $20 per annum, has an assessed valuation of $5 000 for house and lot. Assume that a general change to meter rates is contemplated, as a check to waste of water (the only real object of the use of meters), and that it is important that there shall be no reduction in the revenue received. Assume also that it is found, after investigation, that in this place, one half of the annual expense, including interest and sinking fund charges, is due to the element of " standing ready " and for fire protection. Then $10 should be raised by a sum computed on the assessed value of the property. In this case the rate would be two tenths of one per cent., or $2 on a thousand of the assessed valuation, which, of course, would be the rate for all of the property in this place.

The remainder of the sum that this property should pay for water service, or $10 per year, would be raised by meter rates on the water actually used or wasted and at a rate approximately one half as great as rates that would meet the entire expense. The house in the above example, although having all of the advantages of modern water service, might under the ordinary meter rates, with no minimum charge, by a prudent use of water, pay not more than $7 or $8 per annum, which would reduce the revenue of the works and not be a fair equivalent for the service it receives.

A less valuable house would not pay so much for the " standing ready " element and fire protection, but would pay for all of the water that it used.

In closing its report at this time, the committee wishes to repeat that it still considers its suggestions as suggestions only, but that the discussion and further study of the subject emphasizes its conviction that, in general, a method of meter rates, to be satisfactory, must include some charge for " standing ready " that is entirely independent of the amount of water used, whether the same is one minimum, several minimum charges, or an assessment in some form.

The subject is still open; much must yet be learned by experience. The committee hopes discussion will go on and further data be submitted by members of the association from time to time, to the end that in so important a matter the present uncertainty in opinion and practice may give place to some definite principles of action.

Freeman C. Coffin,
Frank E. Merrill,
C. M. Saville,
H. V. Macksey,
Charles F. Knowlton,
Committee.

A HOMESPUN DEVICE FOR RAISING PIPE IN THE TRENCH.

BY JOSEPH E. BEALS, SUPERINTENDENT OF WATER WORKS, MIDDLEBORO, MASS.

[*Read September, 14, 1906.*]

When making some suggestions as to the practical side of our work as an association, the question was asked if I would present a paper at this meeting. In an unguarded moment, I assented, and hastily gave as a subject that named in the program. I propose to enlarge upon that subject somewhat, and give some bits of experience in raising and in lowering pipe.

In presenting this paper I shall make no pretension to literary merit, but propose to tell as plainly as I can how I accomplished some things on which I had no previous instruction and knew of no precedent to follow.

In the course of events the authorities of the town decided to lower some four or five hundred feet of street which passed over a knoll. The new grade would leave our pipe dangerously near the surface, and we decided that it must be lowered. The problem for us was, how to do it and keep the supply of water on all the time. About all the instruction we could get was that the way to do it, was — to do it. Following the line of the pipe we dug out the old trench down to the pipe, digging it rather wide, and then dug down beside and under the pipe to the depth at which we wished the pipe to lie, leaving bridges across the trench under the pipe just back of the bell ends, on which the pipe rested until we were ready to lower it. We then went back and forth along the trench lowering each bridge just a little, and, after a little coaxing, the pipe just lowered itself. For want of any better knowledge we have since lowered another section in the same way.

At another time our town authorities had decreed that a certain section of street across a valley for a distance of some four hundred feet should be raised. As this would put our pipe to an undesirable depth we decided that the pipe should be raised. The problem with us was, — how to do it. And it is OUR solution of the problem that gives the title to this paper. Somebody had presented a paper before this association describing a method of raising pipe by means of a series of screws. As a set of screws sufficient to do the work would cost more than the pipe was worth, we considered that, while the plan was an elegant one from an engineer's standpoint, it would be cheaper for us to throw the pipe away than to try that method. We then planned to do it by putting a derrick over the pipe and with a differential chain pulley raise it a little at each joint, going back and forth. This was too slow. The men did not feel as if they were accomplishing anything. We had some men in our gang who had worked in a railroad track gang and knew the power of a claw-bar. We borrowed such a bar and railroad tamping iron. We took two pieces of 4 x 6 timber some six or seven feet long, and placing them about two inches apart, nailed a piece of board across the timbers on the upper and under side at each end. We had a short-linked log or timber chain on the job, and dropping the chain down between the timbers, we hooked it around the pipe and, bringing it up above the double skid and engaging the claw of the bar across one of the links and between two others, with a block of wood or timber across the skids for a fulcrum, we obtained a strong, powerful purchase, and as the long end of the bar went down the pipe came up with an ease that astonished us. Here, then, we had an apparatus that was easy to handle, quick to apply and powerful in its action. Four men made a full gang to raise the pipe,— one man in the trench to take along the chain and hook it around the pipe, two men to take along the skids and be ready with their shovels to fill under the pipe as raised, and one man with the claw-bar and block of wood for the fulcrum. In this way we raised some three or four hundred feet of pipe, some of it as much as four feet, in a very short time. I should have said that the pipe raised and lowered was six inch. In both cases we had our calking tools ready, and if the joints showed signs of weeping or spurting a few strokes of the hammer would stop it, and when the pipe was raised or lowered to its position every joint was inspected and driven up as needed before covering.

We were a little afraid that when the pipe was changed from a curved line to a straight line the joints would be inclined to buckle, and dug the trench rather wide so that if necessary the vertical curve could be changed to a lateral curve, but we found in each instance that the pipe settled into a first-rate straight line.

There was one hydrant on the line of pipe raised. This we raised by placing our derrick over it and, with a chain pulley, raising it as we raised the pipe. We raised it about three feet, keeping it ready for service all the time.

The pipe came up so easily and settled so finely into its new position, that we felt that we had found a simple method to do a difficult job and that the experience might be worth the telling. If the idea is new the credit for it is due to the man in the trench.

If this paper shall draw out some one who has done the same thing or something better, or if it shall call out any questions, one of my objects in presenting it will be accomplished.

EXPERIENCES IN INTRODUCING COMPULSORY METERAGE, AND RESULTS OBTAINED BY METERING ALL SUPPLIES IN THE TOWN OF BROOKLINE, MASSACHUSETTS.

BY F. F. FORBES, SUPERINTENDENT OF WATER WORKS,
BROOKLINE, MASS.

[*Read September 14, 1906.*]

The title of this paper is somewhat misleading, for, as you all probably know, Brookline is a town, working under a town form of government, although it has a population of about twenty-five thousand to-day, and a valuation exceeding $93 000 000; consequently, all acts of the town must be made in open town meeting in which every legal voter can take part, and the majority vote must prevail.

I think that it reflects great credit on the intelligence and public spirit of the citizens, to vote as they did almost unanimously in favor of metering all supplies, both public and private, as recommended by a committee appointed by the town to look into and report on this matter.

On December 28, 1904,— at the time the vote for a universal meter system was adopted,— about 2 225 meters were in use, metering more than half of the supplies. At the end of July, 1905, every service not shut off, whether public or private, was supplied with a meter, and the number of meters, including elevator counters, had increased to 3 893.

Very little opposition was made by the water takers to the installation of meters on their premises. As might be expected, some feared that the water rates would be much increased, and that they would lose the feeling of freedom in the use of water which they had formerly enjoyed. I think there was one case only, where the owner positively refused to have a meter set on the premises, and in fact the whole work went along more smoothly and with less opposition than was expected.

The introduction of meters resulted in causing a great deal of poor plumbing to be overhauled or torn out completely, and replaced by more modern and better fixtures. The results to the town have been most satisfactory. Considerably less water has been pumped and the revenue has not been decreased, although the books show about $2 000 less collected for the year ending February 1, 1906, than for the preceding year; but this difference is fully explained by the fact that meter rates are not due until the water has been used, whereas fixture rates were payable in advance. Brookline sends no bills until the water has been used.

The town was so well pleased with the results of the universal meter system, that the price of metered water was reduced from fifteen cents per hundred cubic feet to twelve cents for the same amount, a reduction of twenty per cent.

The table which follows shows the effect meters have had in controlling the consumption of water, and leakage through faulty fixtures.

Year.	Population.	Consumption for First 7 months.	Amount of water passing from the reservoir for 24 hours calculated from the rate of flow between the hours of 12 and 4 A.M. for month of August.
		Gallons.	Gallons.
1897	17 000	289 084 197	517 256
1898	17 500	326 275 813	587 780
1899	19 000	392 478 758	592 178
1900	21 500	418 195 744	691 012
1901	22 000	410 635 002	688 625
1902	22 500	422 059 769	644 164
1903	23 000	457 636 465	724 334
1904	23 500	507 438 066	858 831
1905	24 000	513 564 018	617 535
1906	24 500	425 864 505	562 992

It will be seen from the above table that the average amount of water leaving the reservoir between 12 and 4 A.M., for the month of August, 1906, with a population of 25 000, was less than the amount during August, 1898, with a population of 17 500. No leaks of any account have been found in any part of the distribution, and this smaller waste is due to the better care which has been taken of the water fixtures, and the controlling of unnecessary use; by unnecessary, I mean the water which was allowed to run in winter to prevent freezing, and in summer to cool milk and other articles of diet.

The greatest trouble with excessive water bills occurred in tenement houses of the poorer class, where one meter often supplied four or more families. The tenants perhaps failed to promptly notify the landlord of leaks, or were themselves ignorant of any defects in the plumbing. It often happened that owners of property were non-residents, and consequently not easy to reach. The bills in some cases were several times the regular fixture charges. I am glad to say, however, that these large bills are growing less in number.

From a careful study on the part of the writer, it is very evident that the people of Brookline can use all the water that modern sanitary practice requires without stint, and not have bills in excess of the regular fixture charges, provided that the plumbing is kept in order and the water not allowed to run except for legitimate use. So far, no evidence has been found that the sewers and drains are not as clean as they were before the introduction of meters.

Some of the details of setting meters are as follows:

All the meters for *drinking fountains* are placed in boxes in the ground.

A good deal of time was given to the study of the best way of metering the *water-cart hydrants.* It was not considered safe to place the meters on the water-cart hydrants, as street watering in Brookline is continued long after freezing weather sets in. The plan adopted was to set a two-inch Gem meter, which is sure to drain, in a special cast-iron box, twenty inches in diameter and thirty inches deep, placed in the sidewalk near to the post. The meters can be easily read, and removed for test and repairs.

A larger part of the *house meters* were set in cellars, and boxed where in danger of freezing. All meters are so set that they are easily interchangeable with any other make of the same size. The cost of setting meters varied in different houses, but, as a general thing, a man and helper set from eight to ten meters per day.

A few words in relation to the maintenance and care of meters:

Our experience shows that it costs less to read and change meters than it did to inspect the water fixtures and see that the regulations governing the use of hose, etc., were properly observed. It is our custom to so plan our work that the reading can be done by our regular men. It has always been our policy to keep the meters in good repair so that they shall measure the water accurately as long as they are in service. We do not wait for a meter to break down or wear out. Once each year we look over the record of all meters carefully, and if there is any indication or even a suspicion that the meter is registering less than it should, it is taken out and tested, and repaired if necessary. When a $\frac{5}{8}$-inch meter has registered one hundred thousand cubic feet, it is removed and thoroughly repaired, even though it appears to be in good condition.

We believe that it is better for a town or city to keep the meters in the highest state of accuracy for two reasons; first, the revenue will be larger, and, second, there will be less trouble in the collection of the bills. It is a fact, strange as it may seem, that the water taker will always consider the smallest bill received as the correct one, and consequently, if a bill becomes small owing to a failure of the meter to measure all the water passing through it, it will form the basis of comparison with the bills which follow and which justly charge for the quantity of water used, and no amount of explanation will quite convince the taker that he is not paying more than he should.

The per capita rate of Brookline is large, owing to the great amount of water used on several large estates where comparatively few people live, and by the town in its various public buildings, and for watering streets. The per cent. of metered water used by the town for the last six months of 1905 amounted to 20.7 per cent., or fifteen gallons per capita for a population of 25 000. During the above period of time the meters accounted for all except 14 per cent. of the water pumped.

Tables which are annexed were taken from the report of the Water Board for the year ending January 31, 1906, and show in detail the amount of water pumped and consumed in connection with the public and private service for the six months from June 15 to December 15, 1905:

SUMMARY OF WATER RECORDED BY METER FROM JUNE 15, 1905, TO DECEMBER 1, 1905, AND WATER PUMPED DURING THE SAME TIME.

Total number of gallons of water recorded by meters in private buildings	247 610 902	
Total number of gallons of water recorded by meters in public buildings and in public places	59 945 250	
Water used for flushing sewers, mains and hydrants; used at fires, by steam rollers, for puddling trenches of the sewer department, water department, Telephone Company, and flooding playground	5 062 500	
Total	312 618 652	
Total water pumped during this time	363 666 737	
Water not accounted for	51 048 085	
Per cent. not accounted for		14.0
Per cent. of metered water used by the town		20.7
Per cent. of metered water used by private consumers		79.3

DETAIL OF WATER USED BY THE TOWN.

	Gallons.
Bath house	10 066 500
Miscellaneous public buildings	1 011 000
Fire Department building	604 500
Public schools	5 623 750
Street Department	146 250
Water Department	5 527 500
Drinking fountains	4 120 500
Watering streets	32 840 250
Flushing sewers, mains, hydrants, fires, steam rollers, puddling trenches, and flooding playgrounds	5 062 500
Total	65 002 750

WATER SUPPLY PROBLEMS ON THE ISTHMUS.

BY CARLETON E. DAVIS, DEPARTMENT ENGINEER, BOARD OF WATER SUPPLY, CITY OF NEW YORK.

[*Read September 12, 1906.*]

Among the assets of the French Panama Canal Company which were turned over to the United States for the $40 000 000 purchase price of all rights and properties, were about 2 500 buildings of one kind or another. These were clustered in camps along the entire line of the canal, from La Boca at the Pacific end to Cristobal at the Atlantic end.

The French showed good judgment in locating these camps. High ground was selected if possible, where natural drainage was good, and where the refreshing winds that prevail through a large part of the year would have free play. No finer location could be found than that of Ancon Hospital on the side of the hill overlooking the city and Bay of Panama; while Cristobal, with its avenues of palm-trees, and the surf from the Caribbean, has a wonderful charm.

All the larger camps had more or less of a water supply. The more important houses had shower baths attached; the Ferdinand de Lesseps house at Bas Obispo had a swimming pool annexed; Ancon Hospital, and the Charles de Lesseps house at Cristobal, had bath tubs and water-closets. But all plumbing work was rather crude and clumsy according to our present ideas, and the general run of the houses were supplied with water from outside hydrants only.

The amount of water furnished was small. In some cases a gravity supply from springs was obtained, but in general, water was pumped from the nearest brook or river.

These water works were installed in the larger camps; but every camp, great and small, and every building, whether house, storehouse, or shop, had tanks for collecting rain water from the roof, and every tank was a mosquito breeder.

PLATE I.

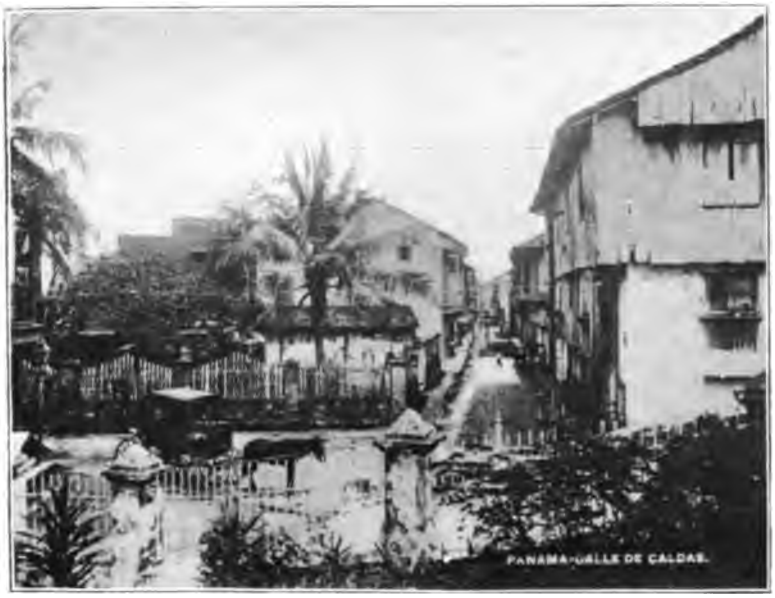

FIG. 1. TYPICAL STREET IN PANAMA.

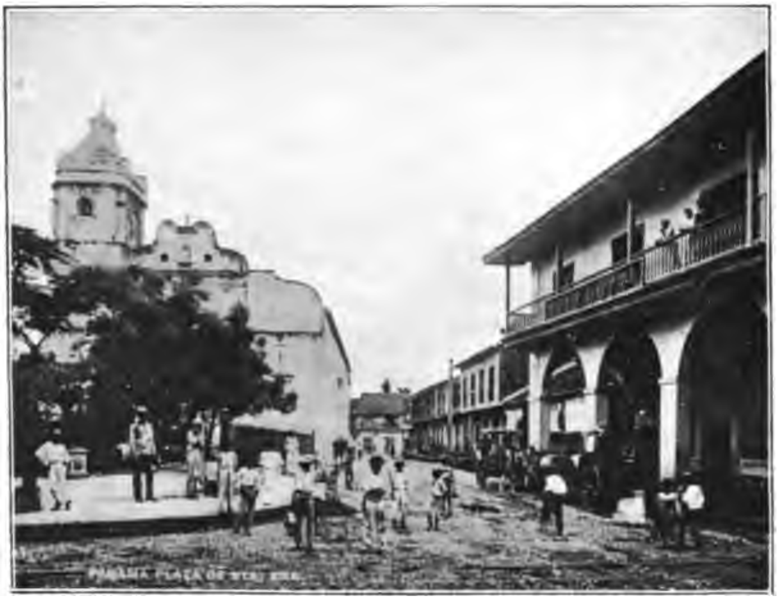

FIG. 2. SANTA ANA PLAZA, PANAMA.

Plans of the various camps existed and were turned over to the Canal Commission with the rest of the French property. The water works were shown on these plans with a fair degree of accuracy.

Not much of the French property was of any permanent value. The machinery was obsolete. The buildings had been eaten up by ants and rot, and had to be practically rebuilt; and the water works could, at the best, be patched up for temporary use only.

The French record of mortality at Panama is well known. The Americans have found the Isthmus a reasonably healthy place. This change is due to the advance in the knowledge of tropical medicine, and to the full control which the United States has obtained through its treaty with Panama.

The French were handicapped. Even if they had had the knowledge of the causes and means of prevention of malaria and yellow fever which science possesses to-day, they would have lacked the power to enforce proper precautions. Their concession gave them no police authority, and even in the United States it appears that health regulations must sometimes be backed up by physical force in order to be effective.

The treaty between the United States and Panama gives the former full sovereignty over the Canal Zone, a strip extending five miles each side of the canal, excepting the cities of Panama and Colon; and in these cities, while sovereignty is reserved, the United States is given control of quarantine and health matters. The treaty further provides that the United States shall install water and sewerage systems in Panama and Colon, and stipulates that water and sewer rates shall be collected sufficient for the amortization of their cost, principal and interest, in fifty years.

Panama City, when the United States took over the canal, had from 15 000 to 20 000 inhabitants. The buildings varied from the rather imposing cathedrals down to little 8 x 10 shacks and palm-leaf huts. The streets were narrow, though fairly well laid out, on an approximately rectangular system. The principal streets were poorly paved with small, round cobbles. There was an electric-light plant, and a ten-ton ice plant, both of which were in operation at intervals. There had been an electric railroad and a gas works. There were a few drains, some of them very old, but the city had never had a public water supply. The inhabitants depended entirely upon rain water collected in tanks and cisterns, and upon a few wells on the outskirts of the town. Water was sold from house to house at one cent gold per gallon. At the height of the dry season, when cisterns and tanks were exhausted and the wells were low, considerable actual suffering for lack of water frequently occurred among the poorer classes.

Colon, a city of 7 000 or 8 000 inhabitants, was formerly called Aspinwall, but its reputation for health was so bad that its name was changed. It was the Atlantic terminus of the Panama railroad, and except for this it had no particular reason for existence. The island of Manzanillo, on which it was built, was only a foot or two above sea level, and at high tide all the back streets were more or less flooded. The general aspect of the place was anything but prepossessing, although some of the railroad buildings on the water front were very attractive.

The Panama railroad had at Colon a water supply of 60 000 to 70 000 gallons per day capacity, collected from a small watershed at Monkey Hill. This was sufficient, however, only for the needs of the railroad and steamships. The general population of the city depended upon rain water, as at Panama.

The interest of the Canal Commission in the condition of these two cities of Panama and Colon was vital. The two chief diseases with which the French had to contend were yellow fever and malaria, both of which are transmitted chiefly, if not wholly, by the bite of infected mosquitoes. Eliminate these mosquitoes, and yellow fever and malaria will disappear.

The stegomyia, or yellow fever mosquito, breeds principally in clear water, and finds ideal conditions in tanks, cisterns, gutters, etc. The anopheles, or malarial mosquito, prefers swampy water.

The city of Panama was feared as the yellow fever center and the point from which cases would spread along the Zone. Not many cases existed when the Americans first went there, for the reason that the population had become largely immune. There were enough non-immunes, however, coming in from time to time, to keep up the succession of infected mosquitoes, and a case of yellow fever was imported every little while from Guayaquil or some other South American port. With the advent to the city

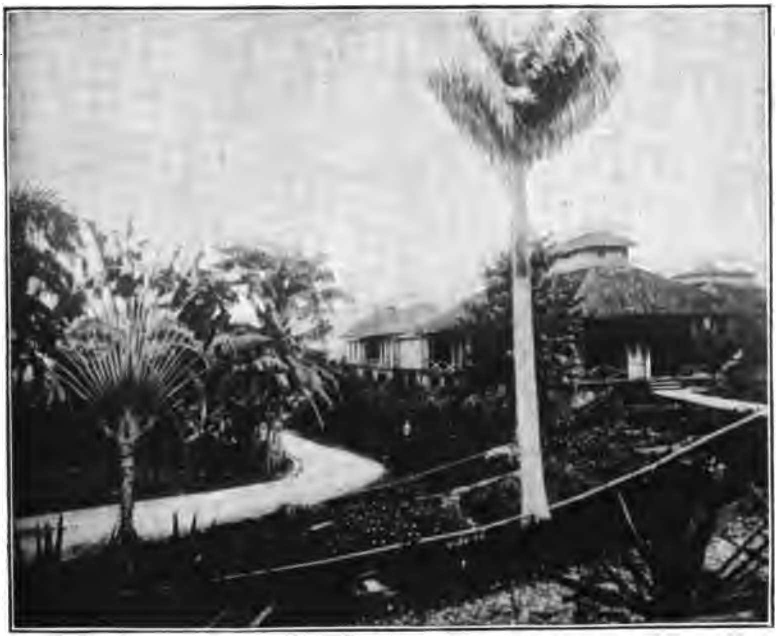

FIG. 1. ANCON HOSPITAL.

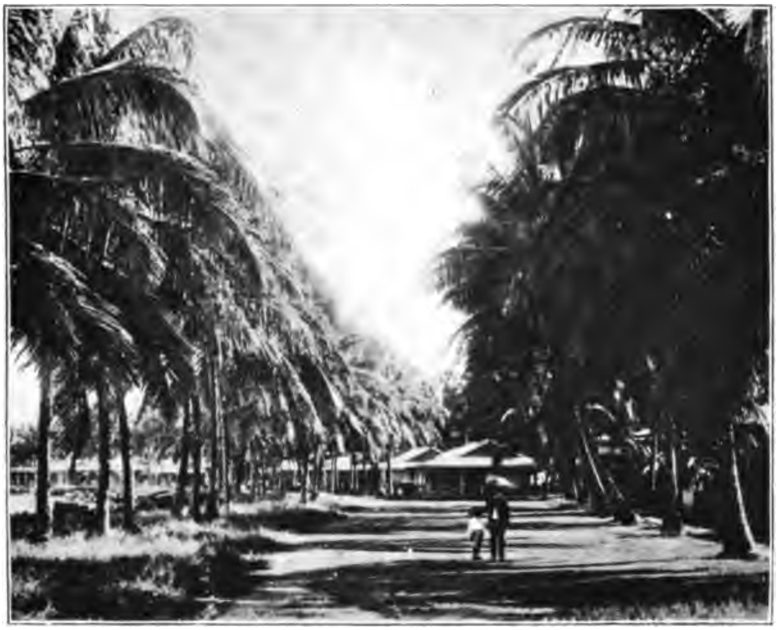

FIG. 2. PALM AVENUE, CRISTOBAL.

of large numbers of non-immune Americans, canal employees and others, there was nothing to prevent a most serious outbreak of yellow fever, unless the mosquitoes could be suppressed.

And conditions in Panama were particularly favorable for the breeding of the stegomyia. With water at one cent a gallon, the Panamanian looked on the water man as his enemy and a rain storm as a blessing. Naturally, every receptacle a family possessed would be filled with rain water at each storm. This water was carefully saved for use, meanwhile serving the mosquitoes' wants admirably. Regular tanks and cisterns could be screened to a certain extent; but no inspection, however rigid, could stop this practice of a whole city, until there should be a public supply, making it easier to get fresh water for each domestic need than to store it.

The same reasons, though perhaps in a less degree, made it necessary to abolish all rain-water receptacles along the line of the canal and at Colon. Panama, from its large population and close commercial intercourse with South American ports, was looked upon as the most probable originator and distributor of yellow fever. But even if cases should occur there and get out along the line, the fever could not spread if the stegomyia had been destroyed.

Water supplies, then, over the entire isthmus were very essential from their indirect relation to the extermination of the stegomyia and yellow fever, in addition to the usual necessity existing for an uncontaminated supply for the thousands of canal employees that would be required. In the tropics, moreover, liberal facilities for bathing should be looked upon as a good investment from a business standpoint alone.

Water would be needed also for mechanical purposes as well as for domestic uses, for steam shovels, locomotives, and drills, and for fire protection.

The necessity of these water supplies as an important feature of the general sanitary improvement of the isthmus was recognized from the outset by those in authority, and they were provided for in the treaty with Panama as mentioned above. The Isthmian Canal Commission made them one of the matters of first consideration upon their taking over the work from the French.

The French company, pending the sale and transfer of their property, had not stopped work; though they had continued it with an organization and force only sufficient to prevent the lapsing of their concession. The transfer was made from the French to Major Black of the Army Engineers, representing the United States, and the old canal organization was carried on by Major Black until the chief engineer, Mr. Wallace, and the chief sanitary officer, Colonel Gorgas, reached the isthmus, the latter part of June, 1904. The engineers in charge of water works and sewers, under the direction of the writer, reached Panama three weeks later.

The Isthmus of Panama, like all Central American countries, is of volcanic origin. At the line of the canal it is about fifty miles wide from ocean to ocean. Along the Atlantic coast there is a margin ten or fifteen miles wide not greatly above the sea level, but in general the country is hilly, the divide lying about ten miles from the Pacific coast, and reaching a height of six hundred or seven hundred feet. Large masses of basalt are found, in addition to softer varieties of rock. Clay is the predominant earth.

Rainfall varies from sixty inches on the Pacific coast to one hundred and thirty inches on the Atlantic coast, being about ninety inches at Culebra on the divide. The year is divided into wet and dry seasons. As a rule, the former begins in the month of May and continues till December, when the dry season sets in and lasts practically without rainfall for four or five months.

Streams are numerous. As might be expected from the amount of rainfall and the nature of the country, they are often very turbid in the wet season. In the dry season they are clear and have only slight color.

The water works for the city of Panama were taken up first and pushed in advance of any others. It was estimated that the city would have a future population of thirty thousand. There is no manufacturing in Panama now, and probably never will be. The character and habits of the population are such that a large consumption of water need not be expected. Two million gallons per day, or about sixty gallons per capita, was taken as the necessary amount to supply.

Some years previous a franchise had been secured by a private company for the introduction of water, but one of the periodical revolutions had stopped proceedings before construction had more than begun. This company had planned to take water from the Juan Diaz River, about fifteen miles east of the city, — an excellent source. But the property holdings of the local owners of the old water company, and other practical reasons, prevented the serious consideration of this source for the new works.

A ground water supply was considered, but the volcanic origin of the country was not favorable to underground water. Some investigations were made without results. Borings made for the canal work proper had not indicated the presence of a supply of water, except near Colon, where salt water was found.

Final selection was made of the Rio Grande at a point about ten miles from the city, and a little to one side of the Culebra cut. The Panama railroad crossed over the river, at the point chosen, on a plate girder bridge. The dry weather flow of the stream would not be sufficient for the proposed supply, and a storage reservoir was necessary.

The Rio Grande had many advantages as a source of supply. The elevation was sufficient to give a good head in the city. The railroad could be used to transport all material, and the pipe from the reservoir to the city could be laid along the track for nearly the entire distance. Branches could be led into the Culebra cut to supply steam shovels and locomotives, and the various canal camps of Paraiso, Pedro Miguel, Miraflores, Corozal, and La Boca, lying along the route, could also be furnished with water.

At the point selected, the Rio Grande comes down through a narrow gorge of trap rock. A small dam already existed here, having been built in 1889 by Buneau-Varilla, of the old French Canal Company, to supply water for dredging operations in Culebra cut. Buneau-Varilla's proposition to excavate the entire canal by dredging is well known, from his recent advocacy of this scheme before the Board of Consulting Engineers. He has adhered tenaciously to his plan, though the collapse of the old canal company, soon after he had his dredging plant installed, prevented any practical test of the idea in the Culebra cut.

The Buneau-Varilla dam created a reservoir of about 100 000-000 gallons. The drainage area tributary had never been surveyed, but it was estimated at from 4 to 6 square miles. Partial run-off records had been kept by the French for a number of years, and they indicated ample flow to furnish 2 000 000 gallons per day with storage of about 400 000 000 gallons.

The dam itself was of the stone arch type, and an excellent piece of construction. Its crest was at elevation 217 feet above mean sea level. The rails of the Panama railroad, which limited the height to which the dam could be easily raised, were at elevation 242. A hasty survey of the basin showed that at elevation 237 the required net capacity of 400 000 000 gallons would be secured.

The complete system proposed for Panama included the construction of this enlarged storage reservoir at Rio Grande; a 16-inch cast-iron supply pipe line, 10 miles long, from Rio Grande to a 1 000 000 gallon distribution reservoir at Ancon Hill; and a distribution pipe system throughout the city, the latter requiring about 10 miles of cast-iron pipe in sizes from 20 inches down to 6 inches. The total estimated cost was $440 000 gold, and the work has been done inside of this figure.

There was some question as to what effect storage would have on water in the tropics. The small reservoir, already existing, had flooded its area without any cleaning or stripping, but in the fifteen or sixteen years that had elapsed, the influence of the rank tropical growth that was submerged seemed to have been entirely eliminated. Directly back of the dam was a mass of logs, branches, and vegetable matter, material brought down and accumulated there by the frequent floods. Decomposition was going on at this point, and water discharged at the lowest outlet in the dam smelled of hydrogen sulphide. The remainder of the reservoir was entirely free from anything objectionable; the water was clear and almost colorless and tasteless. Grass was growing in some places where the water was only five or six feet deep, but no objectionable growths appeared.

Samples of the water were examined with such limited appliances as were on the isthmus at that time, and nothing deleterious discovered. Perhaps the most satisfactory information was the fact that the water was used regularly by some of the laborers in Culebra cut, and found both agreeable and wholesome.

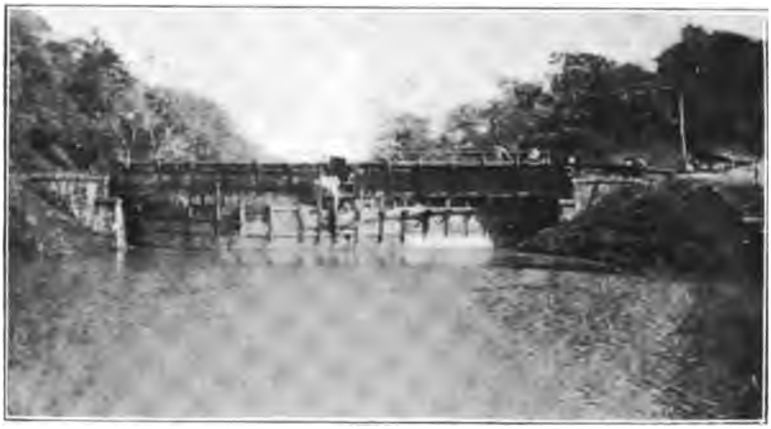

FIG. 1. RIO GRANDE DAM DURING CONSTRUCTION.

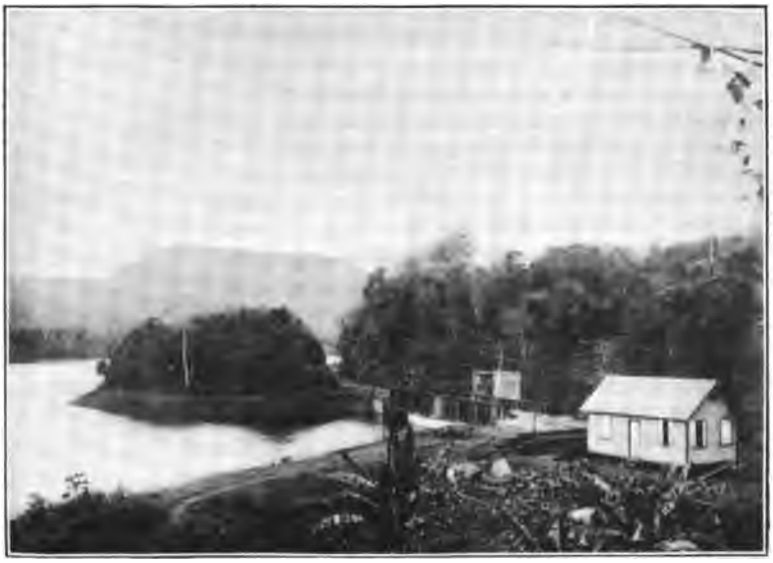

FIG. 2. RIO GRANDE RESERVOIR, PANAMA WATER WORKS.

The sides of the proposed new basin were steep, giving very little area with less than 20 feet depth of water. The average depth of water would be about 40 feet. The watershed was practically uninhabited, and was controlled by the Commission.

Investigations for the water works were begun July 21, 1904, and the system as outlined was authorized by the Canal Commission on August 9. Work on the reservoir was begun immediately thereafter, all work being executed by forces in the employ of the Commission.

There were at this time about six hundred laborers, largely Jamaica negroes, working in the Culebra cut, a continuation of the old French organization. There were in addition perhaps five hundred or six hundred more laborers scattered over the isthmus, who were available for work. Some of these were new arrivals; a good many had been there since active French operations.

Negroes are susceptible to malaria. At least 75 per cent. of those who had been for any length of time on the isthmus were full of it. And malaria is just as potent in taking the energy from a negro as from a white man, which accounts in part for the often spoken of inefficiency of the Jamaican.

At the time the water works were being started, the Department of Health was being organized to get the hospitals into shape, to cut down vegetation, to ditch and drain, and to fumigate; the Building Department was getting ready to repair old houses and to build new ones; the Material and Supplies Department was sorting out old French stock, cleaning up storehouses, and preparing to store and deliver supplies; the Mechanical Department was putting the French shops in order and repairing some of the machinery; and at Colon docks were being built and yards and terminals cleared up ready to receive material.

To constitute the forces of the various departments there were only these 1 000 or 1 200 Jamaicans. Each department needed more men; and yet more men were not wanted on the isthmus until there were places to house them, food and water for them, and a chance to care for them, if they should be sick. Each department depended upon and needed the others, and yet in a sense they were rivals. It would have required transcendent genius to have distributed men and supplies equitably according to the various necessities.

As it was with the men, so it was with the material. Too much, coming in before the facilities for handling it were ready, would simply produce congestion, and Yankee ingenuity had a good opportunity to devise ways of getting work done with old French stock.

The order for the cast-iron pipe and valves for the Panama water works was placed in the United States. The first shipment reached the isthmus in January, 1905, the last shipment in May following.

In addition to the lack of men, good foremen were scarce. This perhaps was hardly more than was to be expected at that time, considering the reputation the place carried. In time, however, many good foremen did reach the isthmus.

Work on the Rio Grande reservoir was started under the direction of two of the engineering force, who were at first the only white men on the ground. Black foremen were all that could be secured.

The existing Buneau-Varilla reservoir was drawn down and thoroughly cleaned out. The additional area to be flowed by the enlarged basin, about sixty acres, was cleared and grubbed. All stumps and large roots were taken out, but no stripping of earth was done. Hardwood trees and logs were burned to charcoal for use later. The soil was a hard clay, apparently containing very little organic matter.

The dam as left by the French had its crest at elevation 217, was 40 feet high, 12 feet wide on the bottom, 4 feet wide on top, and was curved to a radius of about 180 feet. This dam was raised a little over 20 feet by extending vertically the top width of 4 feet. A substantial screen chamber in the center of the down stream side served to buttress this enlarged dam, and two smaller buttresses were built on either side of the center.

This extension work was of concrete mixed about 1:3:6, of Portland cement, seashell sand, and crushed trap rock. Old rails were bedded in the concrete. There were very few weeps through this work when the reservoir was filled.

The route of the supply line from Rio Grande to the city followed the gorge of the river for about 3 500 feet on a level grade, before meeting the railroad; the latter, meanwhile, having had a down grade from the dam of about 70 feet to the mile.

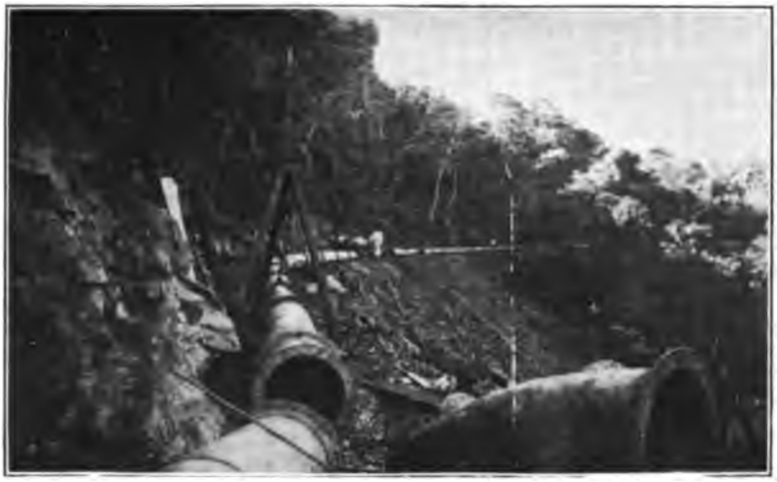

FIG. 1. RELAYING OLD 16-INCH GALVANIZED PIPE FOR PANAMA WATER WORKS.

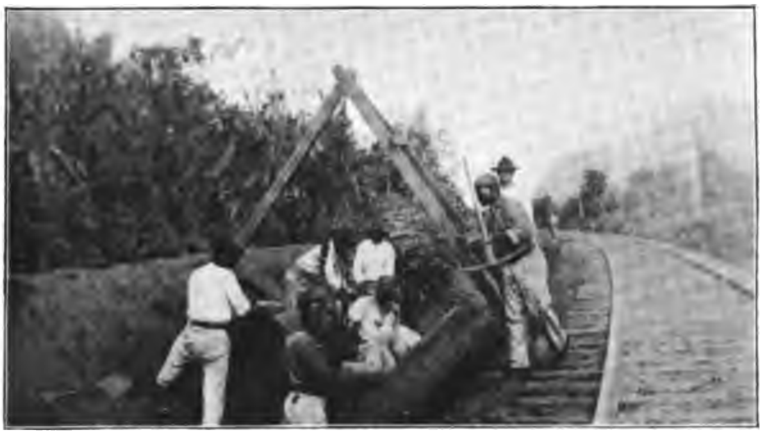

FIG. 2. LAYING SUPPLY PIPE LINE, PANAMA WATER WORKS.

Along the bottom of this gorge Buneau-Varilla had laid a 20-inch galvanized iron pipe to convey water from his dam to the Culebra cut. This line had been left unused since 1889, and was overgrown and hidden by tropical vegetation. The pipes were in 16-foot lengths, of $\frac{1}{8}$-inch plates, single riveted, with flange joints. Barring some dents, which had not injured the galvanizing, the pipes were in first-class condition and practically as good as new. All French material was always of good quality and workmanship.

It would be necessary to protect with concrete any pipe laid in this gorge, as the latter will probably be filled with excavation from the Culebra cut. Under the conditions this galvanized pipe was considered suitable, and it was taken up and relaid as a part of the permanent line. Rubber gaskets were used for the joints. Enough bends were found to get around all curves, with some little aid at certain of the joints where the gaskets were beveled.

This galvanized pipe line was surrounded by 6 inches of Portland cement concrete, mixed about 1:3:5. In actual use under ful head, it has proved very satisfactory. Two small leaks appeared when water was first turned on, but these have since taken up.

From the end of this galvanized pipe to Ancon the supply line was laid alongside the track of the Panama railroad. The pipe was given a cover of about a foot.

Jamaica negroes were used entirely for laborers, pipe layers, and calkers. Some few of them had done similar work in Jamaica, but the majority had to be taught the entire business. The work, however, was very satisfactory. On the ten miles only three cracked pipes developed after the pressure was turned on, and very few joints had to be recalked.

Along the railroad, transportation was, of course, simple. The pipes were unloaded from the cars at night, when no trains were run.

In the city, the ordinary draught animal was a degenerate descendant of the Spanish horse, weighing about 700 pounds. The load these horses may carry is limited by city ordinance; not as a matter of humanity, however, but for purposes of municipal revenue. In hauling sand, the limit is about one third of a cubic yard.

The Department of Material and Supplies imported a number of mules from Chili and New Orleans. They did not stand the climate as well as the local horses, but were usually available for moving the heavier material, and served well for breaking the monopoly of the native teamsters.

The sewer and water pipes throughout the city were laid in the same trench, the latter on a shelf to one side of and above the sewers. The water pipes were given a cover of about 18 inches.

In general, the excavation was good and the trenches stood up well. Clay was the principal material encountered. Some soft rock and indurated clay was encountered that required blasting. The chief difficulty was the old underground drains. The streets were narrow and these drains could not be avoided. Moreover, nobody knew where they were.

Some interesting historical structures were uncovered. An underground passage, supposed to lead from the crypt of the cathedral to the water front, was encountered.

Many predictions were made as to the sickness that would break out in the city where the streets were dug up and the accumulations of centuries exposed. No unusual precautions were taken, except to sprinkle a liberal amount of chloride of lime when a particularly offensive drain was uncovered, and no bad results ensued as a consequence of the work.

The distribution reservoir, mentioned above as a part of the Panama system, is on a peculiar little peak of clay at Ancon, on which there is not much more than room enough for the basin. The walls are of concrete backed up with earth. Water surface is at elevation 137.

The location of this reservoir made it a rather difficult place to reach with material. A 20-inch gage railroad, with Decauville cars and locomotive, taken from old French stock, was laid from the Panama railroad to the foot of the hill; and a hoister, also from old French stock, operated cars on a similar track laid up the side of the hill.

This Ancon reservoir was not essential to the opening of the works, as the pipe was by-passed around it. Its construction was delayed in favor of more important matters until the dry season of 1905 came on; and during that season every drop of water

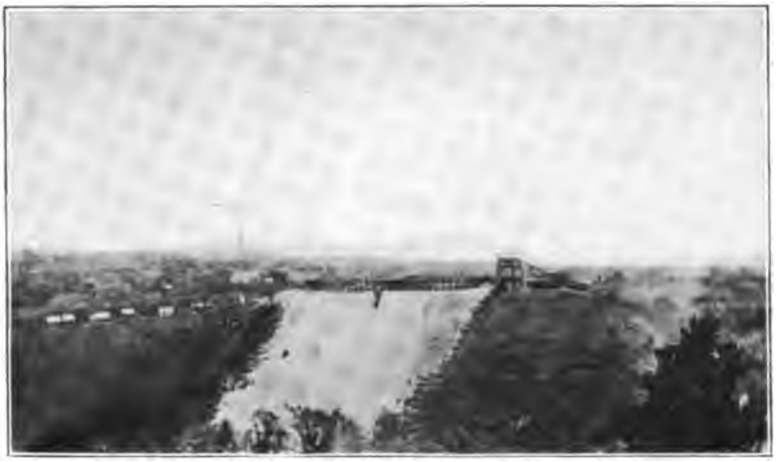

FIG. 1. ANCON RESERVOIR DURING CONSTRUCTION.

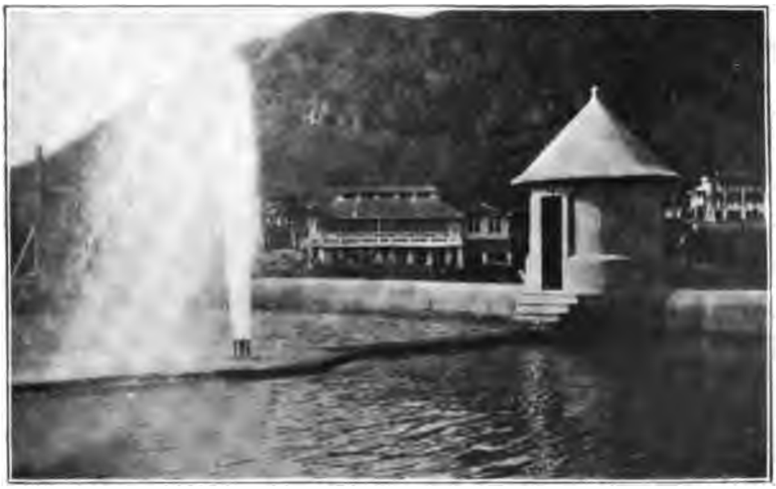

FIG. 2. ANCON RESERVOIR.

in the vicinity was needed for Ancon Hospital, and none was available for concrete.

The formal opening of the works took place July 4, 1905. The fire department of Panama celebrated the occasion, covering themselves with glory and the spectators with water.

At the time of this opening, between three and four miles of distribution pipe had been completed. Connection with the water works and sewers is made obligatory throughout the city, but a reasonable time is allowed for installation of plumbing work. Meanwhile, arrangements have been made at the fire hydrants in the streets so that people can get water for domestic use.

As soon as a district in Panama was supplied in this manner, all rain water receptacles were rigidly prohibited, and wells and cisterns were filled up. The worst yellow fever districts of the city were taken first in the order of pipe laying. The advance of this work has produced a marked decrease in the number of mosquitoes, and has been concurrent with the practical elimination of yellow fever.

For some months after the water from Rio Grande was introduced, examinations showed bacillus coli. For the past eight or nine months, since the withdrawal of the men working about the reservoir, these have not appeared, and very few of any other kind. The supply has been very satisfactory.

In addition to supplying the city of Panama, the Rio Grande system furnishes water to La Boca, Ancon, Corozal, Miraflores, Pedro Miguel, Paraiso, and part of Culebra, all canal towns. As Panama must pay for the system, it is necessary to measure the water; and for this purpose Venturi meters for the main line and branches have been provided.

For the Colon water works, more time was available for preliminary investigations than at Panama. A gravity supply was not practicable. After numerous possible sources were investigated a choice was made of Brazos Brook, lying back of Monkey Hill.

An excellent reservoir site was found on this brook at a point about three miles from Colon. Tributary to the reservoir is a drainage area of one square mile, without habitation. The reservoir has an area of 120 acres, a capacity of 520 000 000 gallons, and an average depth of 20 feet. The sides are steep, and there will be little shallow flowage. Two earth dams, containing about 100 000 cubic yards, are required in the construction of the reservoir.

It is estimated that the watershed will yield easily 1 000 000 gallons per day. Should Colon outgrow this supply, an adjacent watershed of about equal area can be developed. The system has been designed with this in view.

Good data were available for estimating the capacity of this watershed. Reliable rainfall records have been kept at Colon for thirty years. The minimum rainfall is 86 inches; the average, 125 inches; the maximum, 160 inches.

There was also the small reservoir of the Panama railroad, already mentioned, which was built about 1870. This has a total drainage area of 24 acres, an area of 8 acres, a capacity of 20 000-000 gallons, and yields consistently 60 000 gallons per day, or at the rate of over 1 600 000 gallons per day per square mile. This Panama railroad reservoir had considerable shallow flowage and there was a population of about fifty on its watershed. But there was nothing disagreeable to the eye and taste about the water, though, of course, it was not fit for domestic use.

The complete Colon system provides for the storage reservoir on Brazos Brook, with a water surface at elevation 45 above sea level; a 20-inch cast-iron supply pipe from this reservoir to a pumping station near the Panama railroad at Monkey Hill; a 20-inch cast-iron force main from the pumping station to a standpipe; and a distribution pipe system in sizes down to 6 inches.

Like the Rio Grande reservoir, the Colon reservoir has been cleared and grubbed, but likewise no soil has been removed.

The system has not yet been completed.

While the water-works of Colon and Panama were being investigated and built, the canal force all along the line was being increased. One after another the old French camps were occupied, and new large hotels were erected at important points. Water was called for in each camp and the American canal worker demanded more water than did the French.

Temporary arrangements were made by patching up the old French plants and running them until new outfits could be pro-cured, or until the plans of the canal had been sufficiently determined to permit of the camps being permanently located. Most of the machinery had been standing for years. In some cases water had been left in the cylinders, and the boilers had not been cleared out. Pumping stations, like everything else, were hidden away under a dense tropical growth. But nevertheless, almost everything worked, and nothing serious in the way of accidents occurred.

As plans developed, permanent water supplies were authorized. These have all been designed with a view to furnishing fire protection, for the average canal building, especially in the dry season, is a very bad fire risk.

By the middle of 1905 water systems were under construction at Emperador, where a gravity supply from a storage reservoir on the Comacho River will furnish 800 000 to 1 000 000 gallons per day to Empire, Culebra, and Culebra cut; at Gorgona, where a pumping plant is taking water from the Carabili River for Gorgona and the Bas Matachin shops; and at Bas Obispo, where another pumping plant is furnishing water from the Mandigo River for the camps in that vicinity.

All the territory about these streams, above points of intake, is practically uninhabited. A considerable force of men, however, has been working about them during construction. Examination of water shows some coli, as at Rio Grande, though it is expected that they will clear themselves as did that supply after the laborers were withdrawn.

It is generally known that during the past year there has been practically no yellow fever on the isthmus. The average force employed during this time has been 22 000. In the entire force there have been in this period 40 deaths from dysentery and 22 deaths from typhoid.

The maximum force employed by the French was 17 000 men in 1887, and about the same number in 1884. In the former year they had 85 deaths from dysentery in Ancon Hospital alone, the only place where statistics were kept. In 1884 they had 70 deaths from typhoid in Ancon alone.

The canal force is hard to control, and even with pure water supplies throughout the isthmus, there will probably be cases of typhoid in the future.

THE CLEVELAND TYPHOID FEVER EPIDEMIC OF 1903-1904.

BY GEORGE C. WHIPPLE, CONSULTING ENGINEER, NEW YORK, N. Y.

[*Read September 14, 1906.*]

There is one problem in the sanitary conservation of water supplies which the members of the New England Water Works Association have been but rarely called upon to solve. It is that of a city using a lake as a source of water supply, and at the same time using it as a place for the disposal of the city's sewage. To pump water from a lake into the water pipes of a city, to let it pass through houses and factories, through bath tubs and water-closets, through drains and through sewers back into the lake, and then to cause it to deposit its noxious accumulations at some place in the lake so that they shall not by any chance or mischance reach some other place from which the water supply is pumped — in short, to so operate the water supply and sewerage systems as to avoid a closed circuit — is a difficult problem from which you are fortunate to be spared.

We are not altogether spared from it. The JOURNAL of our association, Vol. X, 1896, p. 150, contains a description of the water supply of Burlington, Vt., where the danger of the closed circuit was convincingly demonstrated by our worthy President, Prof. William T. Sedgwick. Acting on his advice, the two poles of the sanitary system, the water supply intake and the sewage outfall, were put so far apart that " sparking " was for a time impossible. But gradual growth of the city so increased the lake pollution that for several years past the sparks of typhoid fever have been crossing the gap and flying into the city. That these sparks have not given rise to a conflagration has been due more to good luck than to adequate insulation.

What has happened in Burlington has happened in almost every city which takes its water supply unfiltered from an adjacent lake. Witness Chicago, Cleveland, Buffalo, Toledo, Lorain and many other places that might be named. I have mentioned Burlington first, not because she has been more careless with her water supply than all the rest, but because she is one of our home New England cities well known to this association, and because the question of purification is now being considered by her city government. If the lake-water is to be continued in use, something must be done to break the unfortunate closed circuit. The most rational, effective, and economical method now known for doing this is by the installation of a water filtration plant. It is to be hoped that steps looking toward the betterment of the supply will be taken at an early date, and before a typhoid epidemic occurs, like that which recently overtook the city of Cleveland while the improvements in her water supply were in progress. This severe epidemic, one of the most important in recent years, has never been described in the technical journals; and it has been thought that an account of it might be appropriately added to the Transactions of this association, already so replete with the lore of epidemiology and public sanitation.

As the Cleveland epidemic was caused by a wholesale and long continued infection of the public water supply by the sewage of the city, a description of the water works and sewerage system should naturally precede an account of the typhoid fever situation.

THE BAY OF CLEVELAND AND THE WATER SUPPLY OF THE CITY.

The city of Cleveland is situated on an indentation in the southern coast line of Lake Erie, about one third of the way from Toledo to Buffalo. The indentation, or bay, is about forty miles long, measuring from Avon Point to Fairport, and about seven miles wide. The city is situated at the deepest point of the indentation. The water within the bay is nowhere deeper than sixty feet and its average depth may be taken roughly as fifty feet. The bottom is chiefly fine sand and clay, but in some places there are deposits of mud and in a few spots the bottom is rocky.

The Harbor. The Cuyahoga River flows into the lake through the heart of Cleveland, dividing the city into the East Side and the West Side. (See Map, Fig. 1.) At the mouth of the river the Government has constructed piers into the lake on either side about one quarter of a mile long. These help to provide a suitable channel of entry. In front of the river mouth and about one quarter of a mile from the end of these piers there is a breakwater parallel to the shore line, which incloses the harbor. The breakwater has an opening opposite the river. The breakwater west of the opening has a wing which extends obliquely across to the shore so as to almost completely inclose the harbor on that side. There is a small opening in this westerly wing which allows boats to enter and provides circulation of the water in the harbor. The harbor is now open on the east side, but an extension of the east breakwater is being made. Inside this harbor and in the river, dredging is going on almost continuously during the open season, and the material which is dredged is carried out to the open lake and dumped into the water.

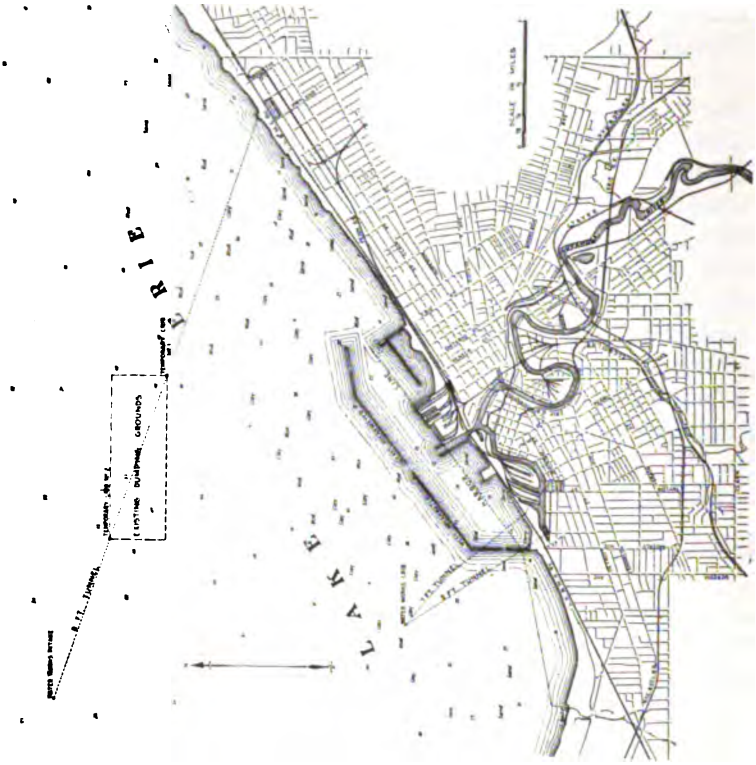

Fig. 1. Map of City and Harbor of Cleveland, Showing Location of Water-Works Intakes, and the Official Dumping Ground.

The Water Supply of Cleveland. The water supply of the city is derived entirely from the lake. The old intake of the water works, often referred to as the " West Crib," or Crib No. 4, is located about 1¼ miles from the shore and 1 mile west of the mouth of the river. (See Fig. 1.) The crib is a wooden structure which protects the intake and serves also as a lighthouse. Water is taken from a depth of 12 to 28 feet below the surface, and only 12 feet from the bottom. From the West Crib two tunnels extend to the Division Street pumping station on the west side of the city, one 5 feet and the other 7 feet in diameter. The former was built in 1874 and the latter in 1891. The normal capacity of the tunnels is said to be 120 000 000 gallons per day. The pumping capacity at the Division Street station is 50 000 000 gallons per day. For about twenty years, or until the spring of 1904, this system furnished the water supply of the city.

In order to supply a greater quantity of water and at the same time to secure water of a better quality, new works were begun in 1890 and completed in 1904. The intake consists of a steel crib located about four miles from the shore and almost opposite the mouth of the Cuyahoga River. This crib is known as the " East Crib," or Crib No. 3. Water is taken at a depth of 10 to 28 feet below the surface, and 22 feet from the bottom. The crib is also used as a lighthouse. From it a 9-foot tunnel extends in a straight line to a pumping station located on the shore of the lake, at Kirtland Street. This tunnel has a length of 26 000 feet. Two temporary cribs, known as Crib No. 1 and Crib No. 2, which were used during the construction of the tunnel, are still standing. They are located at distances of 11 600 and 18 800 feet, respectively, from the pumping station. The nominal capacity of the tunnel is said to be 175 000 000 gallons per day, based on a velocity of 4 feet per second. The present pumping capacity at the Kirtland Street pumping station is 90 000 000 gallons per day.

LOCAL SOURCES OF POLLUTION.

The chief local sources of pollution of the water of Lake Erie in the vicinity of Cleveland are:

1. The city sewers which discharge into the river and along the water front.

2. The Cuyahoga River.
3. The Rocky River.
4. The shore wash and the stirring up of the bottom of the lake by the winds.
5. The dumping of dredged material.
6. The accidental pollution from steamboats.

The Sewage of the City. All of the sewage of the city goes directly or indirectly into the lake. It has been estimated that the sewage of about 225 000 people runs into the Cuyahoga River and that the sewage of more than 200 000 people empties directly into the lake along the water front between Waverly Avenue and Gordon Park.

The Waverly Avenue sewer, which takes the sewage of about 22 600 people, discharges near the west entrance of the breakwater. The sewers at Seneca, Ontario, and Erie streets also discharge near the east side of the harbor. The intercepting system of sewers which is now being constructed is intended to remove practically all of the sewage from the river and the water front and carry it to a point about nine miles east of the harbor, discharging it at a considerable distance from the shore. It will be many years before this system of intercepting sewers can be completed, and it has been suggested to establish a temporary outfall at Marquette Street to be used until the entire system shall be completed. By using this it would be possible to obtain partial relief to the river in a shorter time than by waiting for the completion of the whole system. It seems probable that even after the construction of the intercepting system of sewers the Cuyahoga River will still be a nuisance and that it will probably be necessary to adopt some plan thereafter for the amelioration of its conditions.

Amount and Character of the Sewage. From what is known in general of the *per capita* constituents of sewage it has been calculated that during each day there is discharged into Lake Erie at Cleveland at least 100 tons of solid matter, of which about 70 tons are mineral, and 30 tons organic. Of the mineral matter about 12 tons represents common salt. About 3½ tons of organic nitrogen are also discharged daily and about 3 tons of nitrogen as free ammonia. It has been further estimated that the number of bacteria in the city sewage amounts to more than one hundred million billion daily, of which it is fair to assume that nearly ten million billion are *B. coli* or allied species. These figures, of course, mean little except when taken in connection with dilution as described below. They serve merely to indicate the immense amount of polluting substances which enter the lake and which have to be taken into consideration in connection with the purity of the water supply.

Except in the case of the Cuyahoga River, the quantity of water discharged through the sewers is not sufficient to create currents setting into the lake which preserve their identity for any considerable distance from the shore, and the dispersion of the sewage by the action of wind and wave begins near the shore line. The dispersion of the sewage is materially influenced by its temperature as compared with that of the lake water. The presence or absence of an ice-sheet, the relative temperatures of the water and sewage, and the increased density of sewage due to its mineral constituents, are all matters which must enter into a complete discussion of the problem.

Cuyahoga River. The Cuyahoga River has a drainage area of about 805 square miles. In its upper reaches it receives more or less pollution. The rural population on the watershed is estimated as about 32 500, or about 40 per square mile; the village population (cities and towns of less than 4 000 population), 10 000, or 12 per square mile; the urban population (cities of over 4 000 inhabitants), 55 000, or 69 per square mile; making a total of 121 per square mile. The principal city on the upper part of the river, is Akron, which in 1900 had a population of 42 728. If it be assumed that the sewage of 228 000 of the population of Cleveland drains into the river, the population per square mile on the entire watershed above its mouth becomes 404, of which 352 represent urban population.

The Cuyahoga River in the lower part of its course is tortuous and its flow is ordinarily sluggish. Its surface elevation changes according to the lake level, and the stream has been rightly termed a slack-water estuary. The amount of sewage discharged into the river is so great, its current is so slow, and its volume relatively so small that the water of the river is nearly always foul and ill-smelling. Besides sewage, the river receives the waters from several small brooks, or runs, which are for the most part highly polluted. Immense quantities of manufacturing wastes are discharged into the river or into these runs. From the works of the Standard Oil Company very large quantities of crude oil and other waste products are discharged. This oily matter spreads out over the surface of the water, giving it an offensive appearance and a bad odor, and, what is more important, forms a film which prevents, to a great extent, the absorption of oxygen by the water. As a result of the great amount of pollution which the river water receives and of this lack of oxygen, the stream is nothing more nor less than an elongated septic tank. The suspended matter of the sewage and manufacturing wastes, together with the sediment brought down from the upper portions of the watershed, settles in the lower reaches of the river and forms a thick, black mud. This decomposes and in warm weather bubbles of gas may be seen rising through the water and breaking at the surface. When the river is in flood some of the mud is carried out into the lake, but it is only the severe freshets which scour the bottom of the river to an appreciable extent. In fact, deposits accumulate so constantly that it is necessary to dredge the channel continuously in order to maintain a depth of water sufficient for navigation. It has been roughly estimated that the amount of sediment carried into the lake each year by the Cuyahoga River is in the vicinity of 200 000 cubic yards. Most of this is transported during the spring freshets, when the discharge of the river occasionally amounts to 5 000 or 10 000 cu. ft. per sec. The flood of January 22, 1904, which produced a daily discharge of nearly 25 000 cu. ft. per sec., and which maintained a discharge of more than 10 000 cu. ft. per sec. for several days, caused such a scouring of the river bed that more than 200 000 cubic yards of mud were carried into the lake in one week.

The mud in the river and harbor of Cleveland is polluted. Ordinarily it contains from 1 000 000 to 5 000 000 bacteria per gram and shows the presence of *B. coli* in large numbers. It also contains in large numbers another organism similar in some respects to *B. coli*, and one which has been found to be quite widely distributed through the water of the lake in the vicinity of Cleveland. The samples of mud invariably have an oily odor.

The pollution which the lake receives from the Cuyahoga River has a more important bearing on the quality of the water supply of the city than the sewage discharged along the lake front, because of the greater volume of the river. There is good reason to believe that at times the river flows as a well-defined current out into the lake for a considerable distance from the shore, its waters gradually dispersing and becoming mixed with the water of the lake. The result is that when the conditions are such that this current is directed straight towards the intakes the dilution of the sewage is less, and the pollution of the water supply greater, than it would be if the sewage were discharged uniformly along the entire lake front.

Rocky River. The Rocky River discharges into Lake Erie at a point about six miles west of the city. It has a drainage area of 347 square miles, on which dwells a population of about 15 000 people or 72 per square mile. The river receives only a small amount of direct sewage pollution.

Mud Deposits and the Shore Wash. Through the constant discharge of sewage, manufacturing wastes, and other polluting substances into the lake for many years, the shores of the lake in front of Cleveland are unclean and the deposits along the shores are foul. When these deposits are stirred up through the action of the wind and waves, the suspended matter is carried out into the bay, only to be deposited again when the water becomes quiet. Thus for many years the mud at the bottom of the lake has been gradually becoming polluted for greater and greater distances from the shore.

The streams along the shore have been discharging great quantities of silt and clay into the lake for many years, and while in many places near Cleveland the bottom of the lake is sandy or rocky, there are, according to the government charts, large areas covered with clay or mud. At certain seasons of the year, especially during the spring and fall, when the temperature differentials between the surface and bottom are small, the action of the wind stirs up this clay and mud, and materially increases the turbidity of the water in this portion of the lake.

The Dumping of Dredged Material. The material dredged from the river and harbor has, until recently, been dumped into the lake between the first and second temporary cribs, on the line of the new tunnel. The boundaries of this dumping ground were officially established by the United States Government a number of years ago. The dumping ground was a rectangle formed by north, south, east, and west lines drawn through Crib No. 1 and Crib No. 2. All material dredged from the harbor was required to be dumped within this area, and a float to mark the spot was established by the United States engineers, about ten thousand feet southeast of the new intake. The amount of mud and clay dredged every year from the Cuyahoga River and the harbor of Cleveland is said to be about two hundred thousand cubic yards, which is approximately the annual amount of material carried in suspension by the river during the year.

The night soil of the city is taken in scows and is carried out into the lake eight or ten miles from the intake and dumped. The scows in their ordinary course pass within about half a mile of the new intake.

The effect of the dumping of polluted material from the river and harbor upon the quality of the water in the city was occasionally evident in the analyses. On June 4 an inspection of the dumping ground was made and the operation of dumping witnessed. It was found that the surface of the water in the vicinity of the float was covered with a thin film of oil which spread out over a wide area. This oil came from the mud. A sample of water was collected near the float immediately after the scow had dumped, and a series of samples was taken at intervals of about one quarter of a mile along the line in the direction in which the wind happened to be blowing, namely, towards the east. The water had an oily odor for more than a mile from the dumping ground. The number of bacteria decreased from the dumping ground towards the eastward, but the colon bacillus could be detected in all of the samples. Had the wind been blowing towards the intake, *i. e.*, from the southeast instead of from the west, the oily water would have been driven nearly to the intake of the water supply. Samples of mud from the river and from the bottom of the lake taken on the same day showed marked variations in their bacterial contents. The mud dredged from the Cuyahoga River contained 26 000 000 bacteria per gram of dry material, while the mud from the bottom of the dumping ground contained 31 000 000. A second sample of mud a short distance from the float contained about 20 000 000. A sample from the bottom of the lake at the east end of the dumping ground contained only 125 000, while a sample of sand from the bottom between Cribs No. 2 and No. 3 contained only 154 per gram. Moreover, the last two samples gave negative tests for *B. coli*, while the others gave positive tests. Prior to June 4 samples of water collected at the Kirtland Street pumping station had, in a few instances, distinct oily odors, and it had been observed that when such odors were present the samples sometimes contained the colon bacillus in small numbers. On investigation it was found that these conditions existed when the wind had been blowing briskly from the southeast, and it seemed obvious that the water at such times was influenced by the material deposited at the authorized dumping ground.

On September 3 other samples were collected at the dumping ground immediately after dumping and several hours after that. Samples collected immediately after the scow had dumped showed a high turbidity and large numbers of bacteria near the surface, and also at the bottom, with fewer bacteria at the mid-depth. Three hours later the conditions at the surface had improved but the number of bacteria at the bottom remained high. The test for the colon bacillus corresponded with these results of turbidity.

There has been no evidence as yet to show that the dumping of dredged material has caused an actual infection of the water supply, but evidently the deposition of polluted mud at the point mentioned was a menace to the sanitary quality of the water supply and hence to the health of the community. The matter was reported to the War Department through the United States Engineers, and as a result a new dumping ground was authorized. This was located about two miles from the shore, opposite Dean Street. It consisted of a rectangle 2 miles long and 1 mile wide, parallel with the shore.

Accidental Pollution from Boats. The steamers plying between Cleveland and various other cities on the lake pass within a mile or so of the water-works intake, and some of the fishing boats and scows often pass much nearer. It is probable that the effect of accidental pollution from these boats would be extremely small, yet it is within the bounds of possibility. This accidental pollution is, of course, beyond the control of the city.

Pollution at the Crib. The crib is used as a lighthouse, and this necessitates the constant presence of a keeper. At times, also, when repairs are being made, several men may be employed at the crib for a number of days. The disposal of fecal matter at the crib, therefore, becomes a matter of importance. To allow it to accumulate at the crib would create a nuisance, while to throw it from the crib into the lake would endanger the water supply. The present method consists in carrying the material in a row boat and dumping it into the lake at a considerable distance from the crib. This cannot be done in winter and it is evident that a well-regulated system of disposal, with efficient disinfection, should be maintained.

Pollution by Leakage into the Tunnel. In some cases where a water supply has been drawn from a lake the water has become polluted by leakage into the tunnel or pipe-line. This matter has been given careful consideration, but from the data collected there is no reason to believe that such pollution of the water supply of Cleveland does or can take place.

TYPHOID FEVER IN CLEVELAND.

Past History. For many years the typhoid fever death-rate of Cleveland has been higher than it should be, and there is good reason to believe that this has been due largely to the character of the public water supply. Statistics furnished by the Department of Public Health show that the average typhoid death-rate for the 32 years from 1873 to 1904, inclusive, was 52 per 100 000, while it has varied in different years from 21 to 114. The following figures show the number of years when the typhoid fever death-rate has been between certain figures:

Typhoid Fever Death-Rate per 100 000.	Number of Years when this Death-Rate existed.
Below 20	0
Between 20 and 30	2
Between 30 and 40	8
Between 40 and 50	5
Between 50 and 60	8
Between 60 and 70	6
Between 70 and 80	1
Between 80 and 90	0
Between 90 and 100	1
Above 100	1

Since 1880 there has been a general lowering of the rate, due probably to better general sanitation, to the abandonment of local wells, etc. Thus, during the ten years preceding the epidemic of 1903 the average death-rate from typhoid fever was 37 per 100 000, which is much lower than the average for the entire period. This figure is only slightly above the average for the cities of the United States which have more than 30 000 inhabitants.

The records of the United States Bureau of Labor show that for the six years from 1896 to 1901, inclusive, the average annual typhoid fever death-rate for the 19 000 000 people included in these cities has varied from 33 to 38 and has averaged about 35 per 100 000. The following are the average figures for the six years mentioned for those cities which had more than 100 000 inhabitants in 1900:

AVERAGE TYPHOID FEVER DEATH-RATE FOR SIX YEARS FOR THOSE CITIES WHICH HAD MORE THAN 100 000 INHABITANTS IN 1900.

Name of City.	Rate.
Pittsburgh	120.2
Alleghany	96.6
Washington	65.7
Louisville	58.6
Philadelphia	52.0
Cleveland	50.1
New Orleans	48.3
Denver	45.8
Cincinnati	44.7
Minneapolis	43.0
New Haven	42.6
Kansas City	42.2
Los Angeles	41.2

Name of City.	Rate.
Indianapolis	38.8
Memphis	36.2
Baltimore	34.8
Columbus	33.5
St. Louis	32.4
Chicago	31.5
Toledo	31.2
Paterson	30.7
San Francisco	30.6
Buffalo	28.5
Boston	25.8
Scranton	23.4
Providence	22.9
Omaha	22.5
Newark	21.7
Syracuse	21.6
Jersey City	20.4
New York	19.6
Detroit	18.9
St. Paul	17.7
Milwaukee	17.6
Worcester	17.3
Fall River	16.0
St. Joseph	15.6
Rochester	15.5

It will be seen that of the 38 cities which had more than 100 000 inhabitants at the time of the last census, 32 had lower typhoid rates than Cleveland and only 5 had higher rates.

As a general rule a continued typhoid death-rate above 20 is an indication that something is at fault with the public water supply, and the rate for Cleveland was above this for more than thirty years. During 1903 the city was visited by a severe epidemic of typhoid fever which continued for many months and gave a yearly death-rate of 114 per 100 000, and again during the spring of 1904 another epidemic occurred which caused a death-rate for the year of 48 per 100 000. Had this epidemic not been checked by the use of water from the new intake, it would probably have exceeded in intensity the epidemic of any preceding year. Details of these epidemics are given below.

The statistics do not point to a well-marked seasonal distribution of typhoid fever in Cleveland, although ordinarily the disease has been most prevalent during the autumn, as is the case in most cities. During several years the maximum number of cases occurred in the spring, while the epidemics of 1903 and 1904 both started in the winter. This abnormal seasonal distribution, taken in connection with the general high typhoid fever death-rate of the city and the general distribution of the cases throughout the city, are all facts which point to the public water supply as being the cause of most of the typhoid.

Comparison of the annual typhoid fever death-rates of Cleveland with those of other cities on Lake Erie fails to show any relation between them, and, as will be pointed out later, there is no reason to believe that any of the cities on the watershed of Lake Erie are in any way responsible for the typhoid fever in Cleveland, unless we except those which drain directly into the Cuyahoga River, and even in the case of Akron, the largest city on the Cuyahoga River watershed, no direct correspondence can be discerned from the statistics. The evidence seems conclusive that the greater part of the typhoid fever in Cleveland in the past has been due to infected sewage of the city which has reached the public water supply, and there is further reason to believe that that part of the sewage which enters the Cuyahoga River has been chiefly responsible for it.

Typhoid Fever in 1902. During the year 1902 there was less typhoid fever in Cleveland than usual, the death-rate being only 33 per 100 000 inhabitants, yet even during this year it is possible to detect some relation between the prevalence of typhoid fever and the probable pollution of the water supply. (See diagram, Fig. 2.)

The old intake was so situated that when the wind was blowing from the south or southeast the water of the Cuyahoga River and the sewage of the city would be carried toward it (see map, Fig. 1), and if the wind was strong enough, and the flow of the river sufficient, evidence of the pollution was often shown by the oily odor of the water. Further evidence is furnished by the typhoid fever statistics. In looking over the records for the year 1902 all of the fluctuations in the typhoid fever cases cannot be explained, but it is noticeable that whenever the Cuyahoga River was in flood, and when at the same time the wind was blowing strongly from the south or southeast, thus producing a

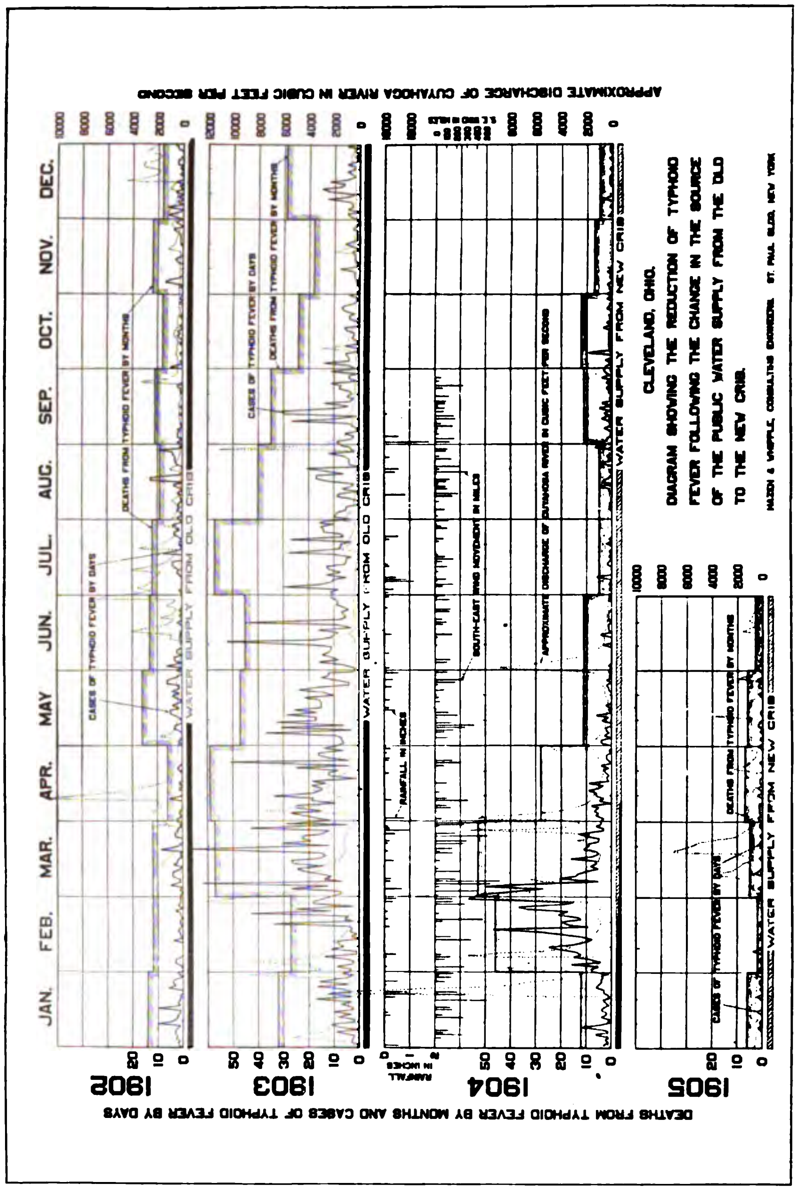
APPROXIMATE DISCHARGE OF CUYAHOGA RIVER IN CUBIC FEET PER SECOND
DEATHS FROM TYPHOID FEVER BY MONTHS AND CASES OF TYPHOID FEVER BY DAYS
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
1902
1903
1904
1905
0
10
20
30
40
50
2000
4000
6000
8000
10000
12000
CASES OF TYPHOID FEVER BY DAYS
DEATHS FROM TYPHOID FEVER BY MONTHS
WATER SUPPLY FROM OLD CRIB
WATER SUPPLY FROM NEW CRIB
RAINFALL IN INCHES
SOUTH-EAST WIND MOVEMENT IN MILES
APPROXIMATE DISCHARGE OF CUYAHOGA RIVER IN CUBIC FEET PER SECOND
CLEVELAND, OHIO.
DIAGRAM SHOWING THE REDUCTION OF TYPHOID
FEVER FOLLOWING THE CHANGE IN THE SOURCE
OF THE PUBLIC WATER SUPPLY FROM THE OLD
TO THE NEW CRIB.
HAZEN & WHIPPLE, CONSULTING ENGINEERS, ST. PAUL BLDG. NEW YORK

FIG. 2.

fall in the lake level, an increase of typhoid fever occurred within about ten days or two weeks thereafter. It is noticeable also that floods in the river which occurred when the winds were blowing towards the shore instead of away from it, thus producing a rise in the lake level, were not followed by typhoid fever, and southeasterly gales not accompanied by a moderate flood in the river did not cause a material increase in the number of cases. It appeared to be necessary to have the two conditions operating together in order to cause a pollution of the water at the old intake, sufficient to show a rise in the typhoid morbidity rate of the city. The fact should be noted, however, that a severe west wind sometimes causes the lake level to drop. The following may be taken as typical examples:

There are no data for the discharge of the Cuyahoga River prior to March 12, 1902, hence no comparisons can be made before that date. During the early part of the year 1902, there were 3 days when the number of reported cases of typhoid showed a decided increase, namely, on January 10, January 16, and January 24. It is worth notice that 8 days before January 10 there was a drop in the lake level due to a strong south and southeast wind; 11 days before the 16th, there was a similar lowering of the level from the same cause, and 9 days before the 24th there was also a lowering of the lake level. Yet on the 20th a severe southeast wind was not followed by typhoid fever, unless the slight increase on February 4, 15 days after, was due to it.

In making these and other similar comparisons it must be remembered that the dates when the cases were reported are not always the dates when the patients were taken sick (although the two dates ought not to differ widely, and seldom do except in the hospital cases).

On March 12, 1902, there was a severe southeasterly storm, the total wind movement for the day being 689 miles, and the velocity exceeding 30 miles an hour for nine hours. This was accompanied by a rainfall which produced a slight flood in the river. Eight days later there was a marked increase in the number of typhoid fever cases in the city, and the number would probably have been larger if the wind had not changed on the following day and blown strongly from the west. On May 5 there was a similar flood of the river, accompanied by a southeast wind, which was followed, after 8 days, by an increase of typhoid fever. On July 1, 2, and 3 the river was again in flood, with the wind blowing strongly from the southeast, and after 8 or 10 days there was an increase of typhoid fever. On September 28 there was a moderate flood of the river and a southeast wind which was followed by a slight increase of typhoid fever, and the same was true on August 20 and November 18. Between December 16 and December 23 the conditions of wind and stream flow were for several days so favorable to the pollution of the water supply that they may be said to have given rise to the epidemic which occurred in 1903, and which is described below. On the other hand a freshet, which occurred on April 9, 1902, raised the stream flow to 10 300 cubic feet per second, but at this time there was a strong northeast wind which apparently raised the lake level and protected the intake from pollution, as it was not followed by an increase of typhoid fever. This was also true of the floods which occurred on March 29, June 29, and July 29. On June 15, the river was in flood, but at this time, although the wind was blowing from the southeast, the velocity was very low and no typhoid fever resulted. An increase of typhoid fever on August 17 occurred 9 days after a slight flood in the river when the wind was blowing from the west.

Throughout the year there were many times when the wind blew strongly from the south or southeast, unaccompanied by a high river flow, but so far as can be learned from the statistics these occasions were not followed by typhoid.

It is not to be presumed that all typhoid fever in the city can be traced to the drinking water, because milk, various foods, flies, etc., may spread infection. Yet in spite of this the evidence seems sufficient to show that even in a year when typhoid fever was not more than usually prevalent the connection between pollution of the public water supply and the sudden outbreaks of diseases could be detected.

Typhoid Fever in 1903. The typhoid fever epidemic in 1903 may be said to have begun on January 6, when 9 new cases were reported. This was just 10 days after a heavy rainfall, which increased the discharge of the river and which was followed by fresh southeasterly winds. For two or three weeks previous to this the river had maintained a discharge of more than 2 000 cu. ft. per sec. and the winds had been high, causing unusually great fluctuations of the lake level. On January 4 the stream discharge increased to 4 600 cu. ft. per sec., and between January 7 and January 15 the winds were again strong and the fluctuations of the lake level considerable. Thus, between January 8 and 9 the lake level dropped 0.6 foot and between January 11 and 12 0.9 foot. About ten or twelve days later new cases of typhoid fever became still more numerous, but after January 27 they became fewer. On January 27, 28, and 29, the flow of the Cuyahoga River increased to 8 400 cu. ft. per sec., and on the 30th, under the influence of a strong southwest wind, the total wind movement for the day being 923 miles, the lake level was lowered 0.5 foot, the whole mass of water in the lake being driven eastward. Ten days later the number of typhoid fever cases again increased

On February 2, 3, and 4 there was a second freshet. The discharge of the river reached 8 300 cu. ft. per sec., and another strong west wind drove the water eastward and lowered the level of the lake 1.1 feet. Fifteen days after that there were 34 new cases of typhoid fever reported in one day.

On February 8 there was another drop in the lake level which amounted to 1.7 feet, due to a westerly wind, and fifteen days after there were forty-three new cases reported in a single day. From this time on, through the spring and summer, large numbers of new cases were reported daily. As the sewage of the city became more and more infected with typhoid bacilli a smaller amount of pollution of the water supply would give rise to greater numbers of typhoid fever cases. Under the existing conditions the epidemic was in a sense self-sustaining, the typhoid germs making the circuit from one individual to another through sewer, lake, tunnel, and distribution pipes.

It is impossible to explain all of the fluctuations in the typhoid morbidity during this period, but the data at hand indicate that the wind exerted the controlling influence on the typhoid fever in the city. This is illustrated by the following instances: From February 18 to February 23 the prevailing wind was from the south, and on the 23d the southerly wind movement was 331 miles. This fact would explain the general trend of the typhoid curve during the early part of March, with its climax of 62 cases on March 5, eleven days after the high wind. The flood of February 27 and 28, with its southeasterly wind movement of 616 miles, probably caused the increase in the number of cases between March 10 and March 14, but the effect of this storm does not seem to have produced as many cases as would be naturally expected. This may have been due to the fact that the severity of the storm raised the general lake level in the west portion of the lake, so that the effect of the discharge of the river was less than it would have been otherwise. The largest number of cases reported on any day of 1903, namely, 66, occurred on March 19, and was preceded 12 days before by a southeasterly wind movement of 398 miles, accompanied by a slight flood in the river. After this record-breaking day the morbidity fell to about twenty cases per day. An increase to forty-three cases on the 27th followed about 8 days after another heavy southeasterly wind. On March 30, the wind was in the southeast, and 11 days later there was another rise in the typhoid curve. During March the general lake level rose rapidly and the river discharge steadily decreased. This tended to reduce the danger from pollution, and the typhoid morbidity would probably have been less had not the wind at times continued to blow strongly from the southeast.

During the first three weeks of April there was a general downward trend of the typhoid curve; but the southeasterly storm of April 3. accompanied by a flood in the river, prevented the morbidity from falling as it probably otherwise would have done, while a second storm on the 11th caused the morbidity rate to rise again. Twelve days after this date 51 cases were reported in a single day. After this there was a drop in the morbidity due to a two-weeks period of calm weather.

Early in May the typhoid morbidity again increased and remained high, though gradually decreasing throughout the month, being kept up by constant south and southeast winds. By the first of June very few new cases were being reported, but they soon began to increase again, and on June 11, 52 new cases occurred in one day. This followed 12 or 14 days after some rather violent fluctuations of the lake levels and 10 days after a heavy rain. On the 19th, 45 new cases were reported, 13 days after another southeasterly storm.

Throughout the summer of 1903 typhoid fever was constantly present in the city, and whenever the winds were favorable there was an increase in the morbidity rate. On July 30 there were 30 new cases, 11 days after high southerly winds. On July 17 there were 28 cases in one day, 12 days after a heavy rain. Continued southerly winds during the first half of July were followed by a high morbidity rate during the last half.

During the first two weeks of August there was a slight decrease in the morbidity, but from the 15th to the 20th there was an increase which followed about two weeks after a slight flood in the river. From then until the 9th of September the rate was fairly low. On August 27, however, there was a severe rain which caused the discharge of the Cuyahoga River to rise to 11 000 cu. ft. per sec. The lake level at this time fluctuated considerably and 12 days later the daily number of cases jumped first to 27 and then to 30 and 31.

From this time on throughout the year the numbers of the new cases were comparatively small, but there were few days when no new cases were reported. September was a month of high southeast winds. The total southeasterly wind movement was 2 309 miles. This fact probably explains the constant presence of typhoid fever at that time. During October the southeasterly wind movement was lower and the amount of typhoid fever in the city was also less. On September 17 and 18 there was a heavy rain accompanied by a drop in the lake level, due to a strong west wind which drove the lake water towards the easterly end of the lake. About two weeks after this there was another rise in the typhoid curve. On October 4 there was another rain with a southeast wind, and after 11 days this was followed by a slight increase of typhoid fever. On October 7 and 8 there was a severe southeasterly storm, which caused a slight flood in the river, but this apparently caused only a slight increase in the typhoid curve.

During November the typhoid morbidity rate was relatively low in spite of the fact that there were considerable fluctuations in the lake level. Apparently the sewage of the city was becoming less infected than it had been. On November 11, however, the southeasterly wind movement was 462 miles, and 9 days later typhoid increased slightly. On November 16 and 17 there was another southerly storm which produced a slight flood in the river. This was the beginning of a new period of infection which extended over the two first weeks in December and reached climatical points on December 8 and December 12, both of which occurred about two weeks after sudden drops in the lake level. During the last two weeks of December typhoid fever was continually present in the city, but the amount was small.

During the year 1903 there were 3 443 cases of typhoid fever reported and 472 deaths. The ratio of reported cases to deaths was 7.3 to 1. Under ordinary conditions this ratio is as high as 10 or 12 to 1, and at times as high as 15 to 1. That is, ordinarily, there are 10 or 15 cases for every death. Many of the cases in the city were, of course, mild, and were never reported to the Health Department. Assuming the ratio of cases to deaths to be 12 to 1 we find there must have been in Cleveland during the year 1903 as many as 5 650 cases of typhoid fever.

Typhoid Fever in 1904. At the beginning of the year 1904 typhoid fever was prevalent in Cleveland, but the number of new cases reported daily was quite low, seldom exceeding five. On January 20, 21, and 22 there occurred a memorable flood. The rainfall for the three days was 2.57 inches, while the wind blew strongly from the southeast. Moreover, on the day preceding this storm the southeasterly wind movement was 515 miles. On the 21st the discharge of the Cuyahoga River rose to more than 23 000 cu. ft. per sec., and for more than a week it remained above 5 000 cu. ft. per sec. The flood was so great that it washed out of the river bed immense quantities of mud. From data in possession of the United States engineers it seems probable that at this time more than 200 000 cubic yards of mud were carried down the river into the lake. This is more than the entire amount ordinarily discharged in a whole year. On January 31, just 10 days after the flood, typhoid fever began to increase again and continued to increase until February 10, when 25 new cases were reported in one day. After that they decreased for several days.

On February 6 and 7 another southerly storm caused a second flood in the river. This was much less severe than the one previously mentioned, but the discharge of the stream rose to more than 11 000 cu. ft. per sec. and remained higher than 3 000 cu. ft. per sec. for about a week. The sewage of the city had by this time become thoroughly infected with the bacilli of typhoid fever, so that the effect of a flood on February 7 was to cause the number of cases to increase on February 17 to 47 per day. A week of calm weather followed this storm and the amount of typhoid fever in the city dropped off. On the 13th and 14th of February there occurred a very strong southeast wind, and 10 days later the morbidity rate rose again. A southeast wind on February 21 caused another increase, which carried the number of cases to 57 on February 29. They remained high for several days and then decreased, because of the timely introduction of water from the new crib, as described below.

During the last few days of February another very severe southeast storm occurred. The discharge of the river rose to 11 000 cu. ft. per sec., and remained above 5 000 cu. ft. per sec. for more than a week. During this time, moreover, the lake level fluctuated considerably. The conditions were all favorable for a continuance of the epidemic, and the sewage at that time was probably more strongly infected with the bacilli of typhoid fever than at any other time during the preceding year. Had it not been, therefore, for the introduction of water from the new crib there is every reason to believe that the epidemic would have assumed much more serious proportions than at any time during the previous year, and before the effect of this climax could have passed the conditions again became favorable for further infection of the supply. On March 25 and 26 there was another southeasterly storm which carried the discharge of the Cuyahoga River to 11 000 cu. ft. per sec., and on the 31st of March there was another storm which caused the river to again rise to 11 000 cu. ft. per sec. Each of these storms would unquestionably have given the typhoid fever epidemic a new stimulus and would have produced appalling results. The month of April was comparatively free of southeasterly winds, and the results of this would probably have been to check the intensity of the epidemic.

Before the epidemic, however, could have been checked by natural causes the new water supply was gradually introduced, and with the introduction of the purer water the long typhoid fever epidemic, which really may be considered to have covered about sixteen months, drew to a close.

During the sixteen months from January, 1903, until May, 1904, there were 4 578 cases of typhoid fever reported to the Health Department in Cleveland, and 611 deaths. If we assume the true ratio of cases to deaths as 12 to 1 we find that the actual number of cases in the city during that period was over 7 000. This was practically one case for every 60 inhabitants of the city. It would be a very conservative estimate to place the financial loss of the city due to this epidemic as upwards of $3 000 000.

The introduction of water from the new intake took place as follows: The pumps at the Kirtland Street station were started on February 10, 1904, and the pumps at the Division Street station were finally shut down on April 7. Between these two dates water was drawn from both intakes. Between February 10 and February 22 only a small amount of water was pumped at Kirtland Street, but between February 22 and March 1 about one half of the water was drawn from each crib. Between March 1 and March 15 three quarters to five sixths of the water was pumped from the new crib and between March 15 and March 31, about three quarters. Since April 7 all of the water has been drawn from the new steel crib except for a short time on July 21, when, owing to the necessity of temporarily shutting down some of the pumps at Kirtland Street, it was necessary to pump a small amount of water (about one fifth of the supply of the city) from the Division Street station.

A study of the Health Department statistics shows that the decrease in typhoid fever occurred in steps which corresponded with the progressive increase in the use of water from the new intake. It must be remembered that the period of incubation of typhoid fever is from ten days to two weeks or more, so that any change in the character of the public water supply would not make itself felt in the morbidity rate until after that interval of time. Bearing this in mind the following figures have been compiled from the records of the Board of Health to illustrate the relation between the typhoid morbidity and the water supply of the city:

Period.	Average Number of New Cases of Typhoid Fever Reported Daily.
January 1 to January 31, 1904: Period prior to the epidemic caused by flood	2.84
February 1 to March 5: Period of epidemic corresponding to exclusive use of old supply	20.91
March 6 to March 15: Period of epidemic corresponding to use of one half of supply from new intake and one half from old intake	11 10
March 16 to April 21: Period of epidemic corresponding to use of three quarters of supply from new intake	2.89
April 22 to December 31: Period corresponding to exclusive use of water from new intake	1.03

The epidemic practically ceased about the end of April, as it seems probable that most of the cases which occurred during May were of secondary origin, that is, they were taken from previous cases by more or less direct contact. During the summer of 1904 there was less typhoid in the city than in 1902, which was a favorable year, and much less than in previous years.

At certain times, however, there were slight recurrences of the disease, a few cases suddenly appearing at one time, and the number then falling off, and often becoming zero. In comparing these occasional slight outbreaks with the wind and rainfall records, as was done for the epidemic period, it is noticeable that in some cases the outbreak occurred ten or twelve days after a disturbance of the lake level by a southerly wind or flood. The evidence is not sufficiently strong, however, to trace these cases to the water supply. The increased number of cases during the autumn may be easily accounted for by other causes, and some of them are known to have been imported. It seems possible that a few of the cases in August may have been due to the use of water from the old intake on July 21, but the evidence on the point is not strong.

It must be remembered, always, that typhoid fever is transmitted by other vehicles than water, and that during the autumn, especially, typhoid fever is often present in cities which have water supplies of undoubted purity. People returning from summer vacations often bring the disease with them, and in large cities this is always an important factor.

INVESTIGATION AND RESULTS.

The typhoid fever epidemic of 1903–1904 led to an extensive investigation of the quality of the water of Lake Erie in the vicinity of Cleveland to determine whether or not the water from the new intake could be considered as healthful and wholesome or whether it ought to be filtered. Filtration of the water from the old intake was also considered, as well as many matters bearing upon future policy in the development of the supply. These studies were made by the writer under the direction of Prof. Edward W. Bemis, the superintendent of water works, and extended from February, 1904, to July, 1905. During the summer of 1904 Mr. Langdon Pearse, and later, Mr. George E. Willcomb, assisted in the work as resident bacteriologists. Mr. George H. Benzenberg, C. E., also acted as consulting engineer. The local health authorities, the city engineer's department, and the United States engineers contributed many valuable data, while the laboratory of the Health Department at the Northwestern University Medical College was placed at our disposal. A full report of this investigation is given in the annual report of the Cleveland Water Department for the year 1905.

The report describes studies of the currents in Lake Erie, both general and local, and the effect of these in diverting the flow of the Cuyahoga River and the sewage of Cleveland toward or away from the water-works intakes. The influence of the wind and other factors is also carefully studied. Samples of lake water and the water in the city mains were analyzed daily for several months, while once each week during the summer special samples were taken from the lake at twenty-five stations located on four parallel lines extending outward from the shore and above and below the city. The farthest of these samples was ten miles distant from the shore. Float experiments were also made in connection with the study of currents. All these data are given in the report.

Time will not permit all of these investigations to be described, but the results and recommendations, so far as they bear on the general problem, were as follows:

1. The water of Lake Erie at the Old Crib at Cleveland, which was used until April, 1904, often showed by analysis strong evidences of pollution with fecal matter, especially at times when the Cuyahoga River was in flood, and when a southeast wind was blowing. It was a dangerous source of supply and it should never be used again unless filtered.

2. The water of Lake Erie at the New Crib is almost unpolluted by the sewage of the city and may be considered at the present time as reasonably safe from the sanitary standpoint.

3. Occasionally, under certain unfavorable conditions, minute traces of pollution have been detected by analysis in the water at the New Crib and under extreme meteorological conditions, such as may occur at infrequent intervals, it is possible that a slight and transitory infection of the new supply may occur. The danger of this, however, is extremely small and need not be seriously considered at the present time.

4. As the use of the water from the old intake was gradually abandoned and replaced by that of the new supply, the amount of typhoid fever in the city decreased by degrees which corresponded to increasing proportionate amounts of water pumped at the Kirtland Street pumping station; and since the water from the New Crib has been exclusively used the typhoid fever death-rate in the city has been quite low. During the year 1905, this rate was only 18.0 per 100 000, but it should be observed that the meteorological conditions tending to promote pollution of the water have been recently more favorable than during previous years. It is possible that more serious conditions may increase this rate very slightly. On the other hand, as the scattering foci of infection in the region around Cleveland become less numerous, the rate may drop still lower.

5. After the completion of the intercepting sewer system, the danger of pollution of the water at the New Crib will gradually increase as the city grows, until eventually the quality of the water may be affected by it to an appreciable extent. Should the sewage be purified before it is discharged into the lake this would, cf course, modify the situation; but to purify the sewage of the

city to such an extent as to remove the danger of infection to the lake water would be more difficult and much more costly than to filter the water. It is not likely that such a purification of the sewage will ever be undertaken.

6. The lake water at Cleveland is not appreciably polluted by other than local sources, although there are faint indications of the influence of the sewage of Lorain and the Black River on the lake water a few miles west of the city. There is no general pollution of the Lake Erie water worthy of being noticed at present or likely to be important in the immediate future. Cleveland alone is responsible for the pollution of her water supply.

7. The water of Lake Erie, near Cleveland, is at times objectionably turbid, not only at the Old Crib but at the New Crib, and even for several miles farther into the lake. This turbidity is due chiefly to clay and silt stirred up from the lake bottom by strong winds, but to some extent it is due to the suspended matter carried into the lake by the Cuyahoga River and other streams. It gives to the water in the city a cloudy appearance, and at times causes some complaint.

8. The water from the new intake does not at present need filtration from the sanitary standpoint, but before many years, when the lake water has become more polluted, filtration will be imperatively necessary in order to protect the health of the city. Furthermore, the standard of quality of public water supplies in American cities is rapidly rising, and consumers are more and more demanding water which, besides being safe, is clear, colorless, and attractive.

9. The water of Lake Erie at Cleveland is an easy one to purify, either by the method of slow sand filtration or by mechanical filtration. It is naturally devoid of color and its turbidity is seldom excessive. Filtration of this water would render it eminently satisfactory for all purposes, and, except that it is rather hard, it would be second in quality to none of the large supplies of the country. Even its hardness might be somewhat reduced by chemical treatment before filtration. Inasmuch as either system of filtration is applicable, the selection of the one to be used will be governed by questions of engineering and of cost rather than by comparisons of efficiency.

TABLE No. 1.

POPULATION AND TYPHOID FEVER STATISTICS BY YEARS.

CLEVELAND, OHIO.

Year.	Estimated Population.	Total Deaths.	Deaths from Typhoid Fever.		Per Cent. which Typhoid Deaths were of Total Deaths.
			Number of Deaths.	Rate per 100 000.	
1873	113 025	2 641	68	60	2.57
1874	119 757	2 190	81	68	3.70
1875	126 489	2 962	65	51	2.20
1876	133 221	—	65	49	—
1877	139 953	2 903	82	59	2.03
1878	146 685	2 710	55	38	2.03
1879	153 417	3 038	46	30	1.53
1880	160 146	3 156	70	44	2.21
1881	170 267	3 727	169	99	4.53
1882	180 388	3 156	122	68	3.87
1883	190 509	3 399	123	65	3.62
1884	200 630	3 732	121	60	3.24
1885	210 751	3 574	71	34	1.99
1886	220 872	3 525	113	56	3.20
1887	230 993	4 139	120	52	2.90
1888	241 114	4 414	113	47	2.56
1889	251 235	4 414	185	74	4.19
1890	261 353	5 058	180	69	3.56
1891	273 395	5 204	137	50	2.64
1892	285 437	5 227	167	59	3.20
1893	297 479	5 261	153	52	2.91
1894	309 521	5 663	89	29	1.57
1895	321 563	5 167	117	35	2.27
1896	333 605	4 859	143	43	2.92
1897	345 647	5 007	79	23	1.58
1898	357 689	5 040	121	34	2.40
1899	369 731	5 556	118	32	2.13
1900	381 765	6 104	205	54	3.36
1901*	392 400	5 834	140	36	2.40
1902*	403 032	6 134	133	33	2.17
1903*	414 950	6 799	472	114	6.94
1904	426 992	6 476	204	48	3.15
1905	439 034	6 190	78	18	1.26

* Government estimate.

TABLE No. 2.

NUMBER OF TYPHOID FEVER DEATHS IN CLEVELAND, OHIO, DURING EACH MONTH FROM JANUARY, 1890, TO JUNE, 1905.

Year.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1890	16	5	11	7	14	24	14	21	21	21	10	10	180
1891	17	11	12	7	9	3	9	15	14	20	13	7	137
1892	7	3	12	5	8	18	29	27	22	21	12	3	167
1893	3	9	14	14	17	15	8	23	15	14	11	10	153
1894	9	7	8	4	1	4	7	14	4	12	12	7	89
1895	7	10	10	10	11	11	5	9	17	17	6	4	117
1896	5	10	19	15	14	10	13	15	16	6	11	9	143
1897	5	2	7	9	6	3	7	12	4	10	9	5	79
1898	6	8	3	5	10	11	6	6	4	21	9	22	121
1899	11	8	15	10	10	10	7	10	9	12	10	6	118
1900	7	14	29	33	22	10	12	27	15	14	8	14	205
1901	15	17	10	14	11	13	15	17	7	9	3	9	140
1902	14	12	12	6	16	13	12	9	11	8	12	8	133
1903	32	23	55	66	51	39	54	42	40	22	20	28	472
1904	12	46	53	28	10	10	5	5	11	12	7	5	204
1905	6	13	5	7	6	3	5	8	7	8	6	4	78
1906	1	8	4	4	8	34	6	8	—	—	—	—	—
Average 90 -1904	11	12	18	16	14	13	14	17	14	15	10	10	164

TABLE No. 3.

NUMBER OF REPORTED CASES OF TYPHOID FEVER IN CLEVELAND, OHIO, ON EACH DAY OF THE YEAR 1902.

Day of Month.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	1	0	1	2	1	0	0	2	2	5	0	3
2	2	0	0	0	1	6	1	0	0	0	0	6
3	1	1	1	1	0	0	0	1	2	1	1	1
4	3	3	0	1	0	3	0	2	2	0	0	0
5	2	3	5	0	0	3	0	1	1	0	7	6
6	3	1	1	0	1	0	0	2	2	1	5	0
7	3	0	1	0	3	2	0	1	0	0	1	2
8	2	0	4	0	3	2	1	0	1	0	0	0
9	1	0	4	5	0	0	2	1	0	0	0	2
10	10	0	4	0	0	0	1	1	0	1	0	0
11	4	0	1	0	1	0	3	2	0	0	0	3
12	2	0	0	0	3	1	4	0	1	1	0	0
13	3	4	4	1	5	1	4	1	0	2	2	1
14	1	0	2	0	5	0	0	4	0	1	3	0
15	1	1	2	1	1	1	0	0	1	2	1	3
16	10	1	0	0	4	0	0	13	0	0	0	0
17	1	2	1	0	1	0	8	13	0	1	0	0
18	2	1	0	0	0	0	1	1	0	0	0	1
19	1	0	9	0	2	2	0	0	0	0	0	0
20	1	1	2	1	4	0	1	0	0	0	1	1
21	1	1	1	2	1	0	1	0	0	1	1	0
22	0	0	0	1	4	1	0	2	1	0	1	2
23	0	1	0	0	1	0	1	3	1	0	1	2
24	6	1	3	0	1	1	3	3	2	0	1	1
25	3	3	3	0	6	0	3	3	1	0	2	0
26	4	0	2	0	6	0	1	4	0	1	4	0
27	4	2	2	0	3	0	2	4	0	0	0	0
28	2	1	0	0	1	0	4	9	0	1	1	2
29	0		1	0	0	0	2	0	0	1	3	2
30	1		0	0	0	0	0	1	0	0	0	3
31	2	4	2		2		1	0		0		3
Total	77	27	56	15	60	23	44	74	17	19	35	44

Total number of cases, 491.
Total number of deaths, 133.
Ratio of reported cases to deaths, 3.7: 1.

TABLE No. 4.

NUMBER OF REPORTED CASES OF TYPHOID FEVER IN CLEVELAND, OHIO, ON EACH DAY OF THE YEAR 1903.

Day of Month.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0	3	7	16	6	2	11	10	9	4	0	4
2	3	9	8	21	7	7	8	9	3	14	0	5
3	3	3	27	27	7	16	30	8	2	4	0	0
4	2	2	12	15	9	8	15	5	6	4	1	5
5	2	4	62	25	37	11	11	5	1	5	1	3
6	9	14	7	25	3	15	10	0	1	5	2	3
7	0	1	14	9	31	12	5	0	2	0	2	4
8	8	1	11	19	6	11	13	3	4	0	2	13
9	11	11	16	18	33	11	7	9	27	6	3	4
10	2	6	22	34	17	18	12	8	9	0	8	2
11	2	8	25	18	17	52	13	0	1	1	2	12
12	8	9	14	15	29	17	6	7	30	3	0	15
13	3	0	26	15	17	11	5	3	31	2	2	7
14	10	3	27	19	26	10	5	2	10	2	2	6
15	2	1	16	13	15	8	3	12	4	5	2	12
16	3	4	13	19	15	16	10	17	14	6	2	5
17	7	3	15	1	15	3	28	17	4	0	3	2
18	3	4	33	12	16	8	9	6	2	0	0	3
19	17	34	66	12	21	45	7	13	5	1	2	5
20	3	2	2	8	10	7	7	21	3	4	6	2
21	11	6	21	25	14	5	3	0	4	4	3	2
22	3	4	19	4	24	6	27	4	8	2	1	5
23	6	43	23	51	16	7	6	4	3	6	1	2
24	17	11	22	4	4	4	7	4	11	7	1	0
25	4	25	15	12	4	6	14	6	1	6	1	2
26	16	2	12	16	10	9	14	12	4	2	3	0
27	9	18	43	16	15	8	15	2	4	1	2	2
28	4	18	23	6	12	9	10	3	1	1	1	2
29	1		5	14	12	11	16	4	11	3	0	1
30	7		29	8	3	11	13	7	1	4	1	5
31	4		10		1		2	8		1		0
Total Cases	180	249	644	497	452	364	342	209	216	103	54	133
Total Deaths	32	27	57	59	47	45	57	40	35	24	18	29

Total number of cases during year, 3 443.
Total number of deaths during year, 472.
Ratio of reported cases to deaths, 7.3 : 1.

TABLE No. 5.

NUMBER OF REPORTED CASES OF TYPHOID FEVER IN CLEVELAND, OHIO, ON EACH DAY OF THE YEAR 1904.

Day of Month.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3	8	51	3	0	0	0	0	2	2	0	2
2	1	5	42	6	6	1	1	0	2	0	1	1
3	2	16	27	5	0	0	0	0	0	2	1	0
4	1	4	50	7	3	0	1	1	0	0	2	0
5	6	8	28	5	1	0	0	0	1	0	0	1
6	1	15	5	8	2	0	0	1	3	9	0	0
7	2	12	21	0	2	0	6	0	0	0	1	0
8	11	14	14	7	0	0	0	0	1	1	0	3
9	4	20	13	3	0	0	0	0	1	1	2	1
10	0	25	10	6	4	3	0	0	4	1	0	0
11	1	15	5	6	1	0	0	1	1	1	2	0
12	4	10	8	9	6	0	2	1	3	1	0	0
13	2	7	6	5	0	0	1	5	2	1	0	0
14	2	12	6	3	1	4	0	0	5	1	1	1
15	4	19	16	9	0	0	1	4	0	0	0	1
16	3	26	7	1	2	1	0	2	4	3	3	1
17	1	27	5	2	0	1	1	0	0	0	2	1
18	2	9	6	1	0	1	0	0	1	2	0	0
19	3	17	11	2	0	0	0	1	0	0	2	0
20	1	20	9	3	0	1	2	0	1	0	3	1
21	1	12	9	1	1	1	0	0	1	1	2	0
22	3	13	5	5	1	1	1	4	2	0	2	0
23	3	21	5	0	1	1	0	1	1	0	0	0
24	6	17	10	1	2	0	0	0	2	2	0	1
25	5	32	13	2	0	0	0	2	0	1	0	0
26	4	37	3	2	2	0	0	0	4	0	1	0
27	4	18	3	0	0	0	0	0	1	0	4	1
28	3	15	6	1	1	1	0	0	2	2	7	1
29	4	57	4	0	0	0	0	7	3	0	1	1
30	1		4	0	1	0	0	2	3	1	0	0
31	7		4		1		0	9	0	2		0
Total Cases	95	531	406	102	38	16	16	41	50	34	37	17
Total Deaths	12	46	53	28	10	10	5	5	11	12	7	5

Total number of cases during year, 1 383.
Total number of deaths during year, 204.
Ratio of reported cases to deaths, 6.7: 1.

TABLE No. 6.

AVERAGE ANALYSIS OF LAKE ERIE WATER.

	Feb. 17 — Apr. 4, 1904.		Feb. 17 — Oct. 1, 1904.	
	Division St. P.S.	**Kirtland St. P. S.**	**Division St. P. S.**	**Kirtland St. P. S.**
Physical Examination.				
Turbidity (Silica scale) . .	30	13	24	18
Color (Platinum scale) . .	23	12	18	13
Odor (Arbitrary scale)				
Vegetable	1.7	1.5	1.52	1.31
Moldy	0.4	0.2	0.85	0.13
Oily	0.4	0.0	0.30	0.00 0.05(fishy)
Chemical Analysis.				
(Parts per Million.)				
Nitrogen as Albuminoid Ammonia				
In solution	.118	.094		.103
In suspension	.007	.002		.003
Total	.125	.096		.106
Nitrogen as free ammonia .	.041	.019		.022
Nitrogen as nitrites . . .	.004	.003		.004
Nitrogen as nitrates . . .	.06	.02		.06
Total solids	167.5	150.5		156.5
Loss on ignition	24.0	21.2		23.8
Fecal solids	143.5	129.3		135.0
Chlorine	9.9	8.9		8.2
Hardness (total)	103.8	104.3		105.0
Alkalinity	86.7	89.8		88.7
Permanent hardness . . .	17.1	14.5		16.3
Iron	0.58	0.25		0.28
Bacteriological Examination.				
Number per cubic centimeter	12 538	681	8 278	332
Test for B. Coli.				
(Per Cent. of Positive Tests.)				
0.1 cc.	9	0	21	4
1.0 cc.	27	9	55	14
10.0 cc.	59	27	85	44
Microscopical Examination.				
Microscopic organisms per cubic centimeter . . .	160	113	150	117
Amorphous matter . . .	260	250	260	287

DISCUSSION.

MR. M. N. BAKER* (*by letter*). Every paper of the scope and character of this one may justly be regarded as an important contribution to the somewhat slow but successful campaign now being waged against impure water and typhoid fever. With the main conclusions of the author few, if any, will take issue. It remains to be seen whether the good effects which have followed the completion of the new intake will be more lasting than has been the case at Burlington, Vt. Undoubtedly the typhoid death-rate at Cleveland will soon rise again. If the rise be notable, and that would not be surprising, the possible need of water filtration will be brought to the front. It will then be important to determine (as, of course, should always be known) to what extent other causes than the water supply are responsible for such typhoid fever as prevails.

The paper gives no indication of the efficiency of the local health department as regards running down causes of typhoid, and the possible relation of the milk supply, polluted private wells, and privies and flies, thereto. This point is not raised to question the conclusions of the paper regarding the public water supply being the cause of the Cleveland epidemic of 1903–1904, nor the main cause of the long-continued high typhoid fever at Cleveland. It is doubtless true, however, that other sanitary defects at Cleveland were responsible for a considerable amount of the typhoid prior to the completion of the new intake, and for the larger part of the typhoid since the introduction of the improved supply. It is of great importance that these other defects be remedied, first in the interests of the public health, and second, that no injustice be done the water supply when the typhoid rate again rises.

The ratio of cases to deaths indicates, as noted by the author of the paper, that only a small part of the cases were reported in 1902, and by no means all of them in 1903 and 1904. We can never expect to see typhoid brought within reasonable bounds until all cases are promptly reported to the health department and just as promptly investigated by it. It is sad, but true, that in but relatively few cities are anything like *all* typhoid cases promptly reported, while in fewer yet are the reported cases properly investigated as to probable origin of the disease. Even where investigations are carried out along fairly satisfactory lines the facts secured are rarely used in the most effective possible way for the prevention of further typhoid due to the same general causes. This is not the place to go into a discussion of the qualities needed in a sanitary or health inspector, but it may be said that the necessary qualities for efficient service are lacking in most of the inspectors now in office, and it must be added that relatively few of their superior officers are so trained that they could intelligently judge and act upon reports based on proper investigations of typhoid cases. This is unfortunate for the engineer and the water-works superintendent, since a failure to disclose the facts, or all the facts, bearing upon epidemic or endemic typhoid often throws unwarranted discredit upon public water supplies.

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* Associate Editor, *Engineering News*, New York.

Finally, is it too much to hope that some day, not too far distant, morbidity and mortality statistics will be sufficiently accurate and complete, and investigations of typhoid cases sufficiently general and efficient, to divide the responsibility for typhoid between public water supplies and the other main contributing causes?

MR. GEORGE C. WHIPPLE (*by letter*). Mr. Baker in his discussion refers to typhoid fever due to other causes than water. This subject has been studied by the local health department of Cleveland with a fair degree of thoroughness since the introduction of water from the new intake. This has resulted in bringing to light several sporadic outbreaks due to milk and other causes. These account in part for some of the larger figures showing the number of typhoid deaths by months during the last year and a half. While the epidemic was in progress, the writer was engaged by the health department to make a study of the vended well waters and spring waters of Cleveland. Samples of each were analyzed, and inspections made of the local supplies. The writer agrees with Mr. Baker that the investigation of typhoid fever from these miscellaneous causes is worthy of very careful study.

Mr. Baker also refers to the laxity of physicians in reporting cases of typhoid fever. This matter was taken up by the health department during the progress of our investigation, and the agitation of the subject resulted in a decided temporary improvement. It has been found, however, that since the excitement occasioned by the typhoid fever epidemic ceased, the physicians are falling back into their old lax habit of not reporting cases. Studies of statistics in many places have shown that this is nearly always the case, namely, that during the progress of an epidemic, physicians being on the alert, take pains to report their cases when they occur, while at ordinary times, when the cases are comparatively few in number, they do not report them.

A DESCRIPTION OF THE CONCRETE STEEL-REINFORCED STANDPIPE AT ATTLEBOROUGH, MASS.

BY GEORGE H. SNELL, SUPERINTENDENT OF WATER WORKS,
ATTLEBOROUGH, MASS.

[*Read September 13, 1906.*]

In presenting this paper it is necessary to state the situation and conditions in Attleborough at the time this standpipe was being contemplated.

It was absolutely necessary that some steps should be taken for better fire and domestic protection, as we had only one force main from the pumping station to the town, a distance of nearly four miles. In case anything should happen to this main it would be nearly as disastrous for domestic supply as for fire. Under existing conditions direct pumping was necessary at every alarm of fire. Our storage consisted of a wrought-iron standpipe 30 feet in diameter and 125 feet high, with a total capacity of 661 000 gallons, that being about the daily consumption. The top of this standpipe is at an elevation of 247 feet, about 142 feet above the ground at the corner of County and Park streets, that being representative of our business section of the town. The iron standpipe was erected in 1890, and although the Attleborough water is one of the best in the state for both domestic and manufacturing purposes, it contains carbon dioxide, so that it attacks unprotected wrought iron or steel, but has very little effect upon cast iron. These were the conditions of our storage system in 1904.

On March 16, 1904, it was clearly presented to the commissioners when a fire occurred in the new Second Congregational Church, not then completed. The alarm was rung in at 5.40 A.M.; direct pressure was immediately put on to the main, amounting to 125 pounds at the pumping station and 100 pounds at the center of the town, which was held for twenty-five minutes, when the pressure dropped to 40 pounds. Fortunately the fire was extinguished at about that time, but we realized that there must be a serious break somewhere in the system, as the 3 000 000-gallon pump was unable to hold the standpipe pressure. We soon located the trouble, which was a split pipe in the force main, about one mile from the pumping station and three miles from the center of the town. Gates were immediately closed and our standpipe gave us a pressure of 54 pounds. The commissioners, realizing the seriousness of the accident, and what might have happened had not the fire been extinguished when the break occurred, began at once to make investigation as to a larger storage and an additional force main from the pumping station to the town. The commissioners were desirous of building a reservoir of some type to hold 3 000 000 gallons of water, if possible. We employed Messrs. Snow & Barbour, civil and hydraulic engineers, of Boston, to assist us. The investigation was under the personal supervision of Mr. F. A. Barbour.

Owing to the fact that Attleborough is very level, the highest point available in town, locally called Ide's Hill, rises to an elevation of but 250, or 145 feet above the corner of County and Park streets, that being the center of the town. Fortunately, this hill is on a direct line and about half-way between the center of the town and the pumping station. It was evident that a reservoir was not possible if direct pressure was to be obtained. A standpipe was the only alternative; of what height and capacity remained to be considered.

I will not go into details relating to the daily consumption and the number of hours that the pump should be run from an economical standpoint, but will try and explain, as briefly as possible, the reason for building a concrete steel-reinforced standpipe; I will say, however, that after a careful study of both steel and concrete structures Mr. Barbour convinced the commissioners that a standpipe of either type holding 3 000 000 gallons could not be built with safety; that one 100 feet high and 50 feet in diameter, holding 1 500 000 gallons, would be as large as practicable to give the desired pressure. At this writing we know of no structure, of either steel or concrete, of this capacity. We therefore decided that storage of this size would be the largest possible to obtain. With this size, if built in steel, it would be necessary to have the bottom plates 1¾ inches in thickness. I believe that at the present time there are only one or two manufacturers in this country who roll sheets of this thickness.

The experience gained with the former standpipe seemed to indicate that the life of such a structure may be safely estimated at no more than twenty years. The character of the water supply of Attleborough is such that it has more or less corrosive action on iron, which causes a large amount of rust to accumulate in the standpipe. We estimate that there are nearly two tons of rust taken out annually when the standpipe is cleaned; and besides, quite a quantity would necessarily find its way into the mains and services, thereby causing much annoyance in domestic use.

For the last six years all service pipes from mains to cellars have been put in of cement-lined pipe, as we had a great amount of trouble with galvanized pipe, and we find there has been much improvement under these conditions. Thus the quality of our water naturally led to a consideration of other materials for storage rather than steel plates.

As great progress has been made of late in the combination of concrete and steel, the metal being embedded in the masonry and employed to withstand the tensile stresses, we looked carefully and deeply into this method. At this time there had been built standpipes of this type at Fort Revere, in Boston Harbor, that being 20 feet in diameter and 40 feet high*; also one at Milford, Ohio, 15 feet in diameter and 85 feet high; both giving perfect satisfaction. Although neither of these is as large as that proposed for Attleborough, they were sufficient to indicate the possibilities of this type of construction.

We felt justified in asking for bids on a concrete-steel standpipe, also estimates on steel standpipes of same dimensions. The specifications for the concrete steel-reinforced standpipe allowed the bidders to present plans and specifications according to their own ideas of construction, each one specifying the amount of steel to be used, amount of concrete, and factor of safety, with complete plans and method of construction, confining himself to the general design of foundation, standpipe, and gatehouse; the structure was to be guaranteed by the builders for one year from date of acceptance by the commissioners.

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*Described in the JOURNAL, Vol. 19, March, 1905, p. 33.

After a careful study of all plans submitted and methods of construction proposed, we considered that the Aberthaw Construction Company's bid ($34 000) was the one to accept, if any, for the following reasons: Extra steel reinforcement, richness of concrete, method of construction, and complete plans submitted.

We had an estimate on a steel standpipe of the same size for $37 135, making a difference of cost between that and bid accepted, $3 135.

The advantages of a concrete steel standpipe over a steel standpipe are:

First. The cost would be $3 135 less.

Second. No cost of maintenance.

Third. There seems to be no limit to the life of such a structure; or, in other words, is as nearly indestructible as a structure could be made.

The maintenance of a steel standpipe of that size and with our quality of water would be $400 per annum if kept coated on the inside and painted on the outside, and the probable life only twenty years. It would also be necessary to empty the tank annually to clean out the rust and do the painting, which would probably take at least two weeks. During that time water would have to be supplied by direct pumping, which means continuous expense of not less than one hundred dollars per annum. You can see, by this comparison, that there was much in favor of the concrete steel standpipe over the steel standpipe. It seemed to us, in our judgment, it was far better to accept the concrete proposition.

On September 7, 1904, the contract was awarded to the Aberthaw Construction Company, Boston, Mass., under the general specifications prepared by our engineer, which incorporated those of the contractors.

It was early recognized that the greatest responsibility in construction would lie in obtaining watertight walls. The provision of sufficient steel to resist bursting is a relatively simple matter, although many details in joining, bending, and placing the steel required much forethought and labor. The concrete wall is 18 inches thick at the bottom and 8 inches at the top.

In the construction of the standpipe the conditions were carefully studied, analyses of the sand and stone were frequently made by sifting samples through a series of sieves, and the materials were proportioned in accordance with the results obtained so as to reduce the voids to a minimum.

The stone was crushed on the work and the concrete mixed by a machine mixer, and in general very good results were obtained both in consistency and uniformity. The foundation of the tank is concrete carried below frost line, a very good bottom of hard pan being found at the depth of seven feet.

In making concrete, sand and crushed rock or clean screened gravel are mixed with the cement. The proportioning of these materials is not or should not be a makeshift process. Up to within a few years, it is true, they were mixed in a more or less arbitrary manner, but at the present time the scientific requirements are better understood, and it has also been found that for the same money better results can be obtained by following this more exact knowledge recently acquired. The scheme of proportioning involves the filling of the voids in the stone with sand, and then slightly overfilling the voids in the sand with cement. The denser the mixture, the better the concrete. To illustrate more fully this method, if you take a barrel of apples you can turn a considerable portion of a barrel of beans into the voids between the apples, and to this mixture considerable rice could be added to fill the voids in the beans, and to this again considerable flour added to fill the voids in the rice. In the same way, in making concrete, an endeavor is made to get the stone in different sizes so that the smaller may fit into the spaces between the larger and thus reduce the voids to a minimum.

After the placing of the foundation, the erection of the steel reinforcement for the first seven feet of the wall was begun. This reinforcement is equivalent to the hooping of a barrel or railroad water tank, except that instead of being on the outside it is embedded in the center of the concrete wall. It is necessarily heavier at the bottom or in proportion to the possible depth of water above. As is usual in engineering structures, the reinforcement of the walls was made several times as strong as is theoretically necessary, or in other words, a factor of safety was used. Three bars lapping 18 inches and held together by clips

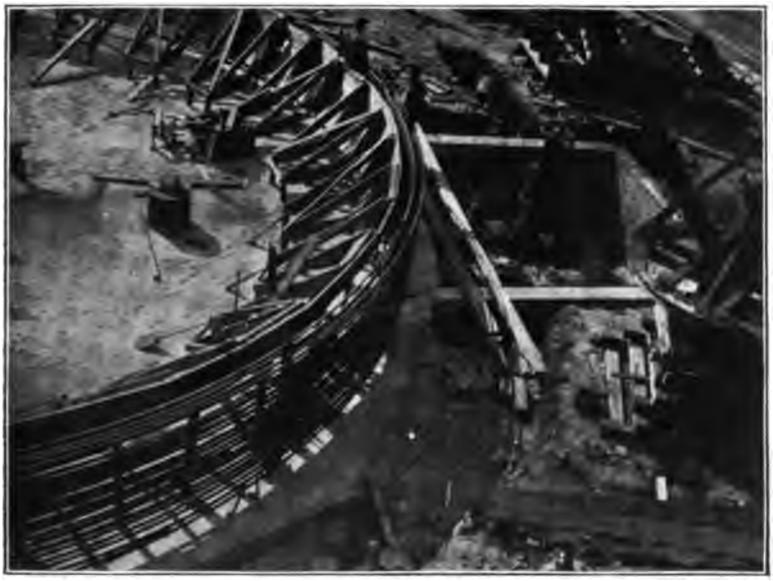

FIG. 1. GATE CHAMBER AND STEEL REINFORCEMENT NEAR BASE OF STANDPIPE.

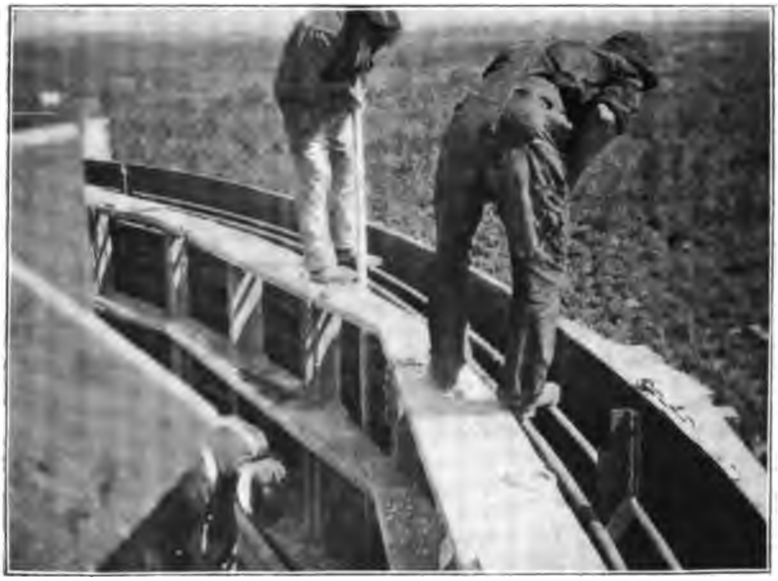

FIG. 2. PLACING AND RAMMING CONCRETE IN WALL OF STANDPIPE

were used to make the circle. Near the bottom these bars were placed in two rows, spaced about four inches on centers, horizontally, the spacing increasing with the height until a point was reached where only one row of bars became necessary. The bars were supported vertically by fifteen channel irons with the flanges drilled at proper intervals and small rods run through these holes to carry the horizontal bars.

After erecting about seven feet of steel reinforcement, the inside and outside forms for the concrete were placed in position. These forms were constructed of wood, seven feet high, and two sets were used, so that after the concrete hardened the lower set could be taken down and moved up above the other set.

The circle of the tank was made by having twelve sections in each set, locking them together at the side by iron clamps. After getting the forms in position the concrete was raised by a derrick to the latforms carried on the interior tower, from which it was shoveled into the space between the inner and outer forms and thoroughly rammed and spaded.

After the placing of the concrete another section of steel was erected, the lower set of forms loosened and moved up to a new position, and the wall carried up in this fashion to its full height.

As soon as the first twenty feet was completed it was filled with water, and during the entire construction the tank was kept filled up to within about one foot of the inside forms. This was done to test the tightness of the concrete, also to keep it wet to prevent cracking.

There were leaks developed after we had completed fifty feet. These gradually grew less as the sediment filled the small voids. When completed, with one hundred feet head of water, there were a number of leaks, but on the entire surface only three jets, these spurting out near the bottom, not larger than an ordinary pin. At this time there had been no attempt to put on a watertight coat of plaster on the inside, but it was just as the concrete was put in between the forms. The amount of leakage was practically nothing.

The tank is covered with a Gustavino tile dome and may be said to be a masonry structure throughout.

In many ways the building of the standpipe required the devising of new methods of construction, and the work was consequently slow, the tank not being completed before cold weather set in. This made it impossible to apply the interior coat of plaster before spring.

I wish you to understand at no time has there been a wetting through of this standpipe over more than from 1 to 2 per cent. of the entire surface. This convinces us that a structure of this type can be made absolutely tight.

On December 27, 1905, we put the new standpipe into commission, and continued to use it until May 15, 1906. The leaks during that time were very trifling, although during extreme cold weather we noticed a scaling off on the outer surface at certain points, beginning five feet from the bottom of the tank and extending to a point about fifteen feet from the bottom of the tank. This was apparently caused by pockets or cavities that must have existed on the outside of the steel, probably caused by the slight moving of the forms when the concrete was being placed.

About May 15, 1906, the Aberthaw Construction Company began the plastering on the inside of the standpipe. The first coat had 2 per cent. lime to one part cement and one part sand; the other three coats were composed of one part sand and one part cement. This was floated until a hard, dense surface was produced; then this surface scratched to receive the succeeding coat. This work was done by experts in that line.

Prior to the plastering the entire inside of the standpipe was thoroughly cleaned and then picked. This was done to insure the bonding of the cement plaster to the surface. There were four coats of plaster put on, and we felt reasonably sure that it would be perfectly tight, as great care was used in applying the same. But upon filling the standpipe this did not give us the result we expected, as we had felt positive that we should have an absolutely watertight structure.

At the time the inside work was being done the outside, where the cement had scaled off from the effects of frost, was repaired by digging around the outside row of steel reinforcement, putting on iron clips made of ¾-inch by ⅛-inch iron bolted through, and then cement was forced into the cavities around these clips by

PLATE II.

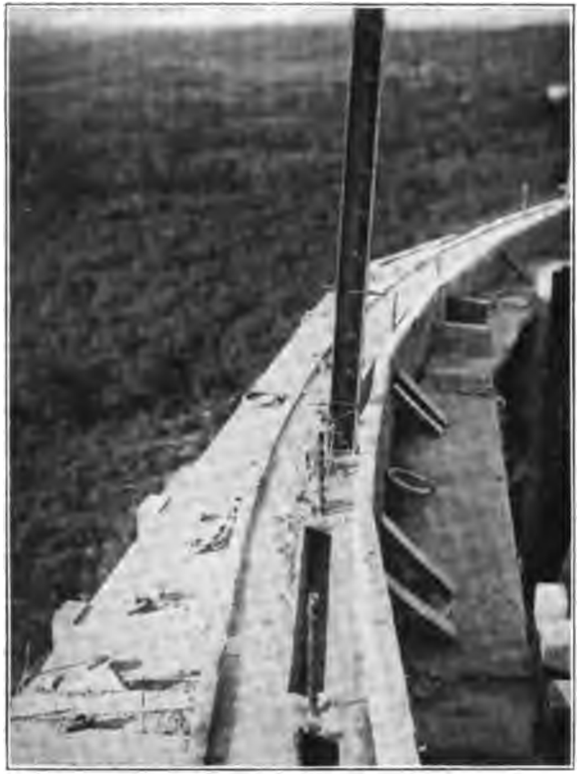

FIG. 1. JUNCTION BETWEEN TWO SECTIONS OF CONCRETE WALL.

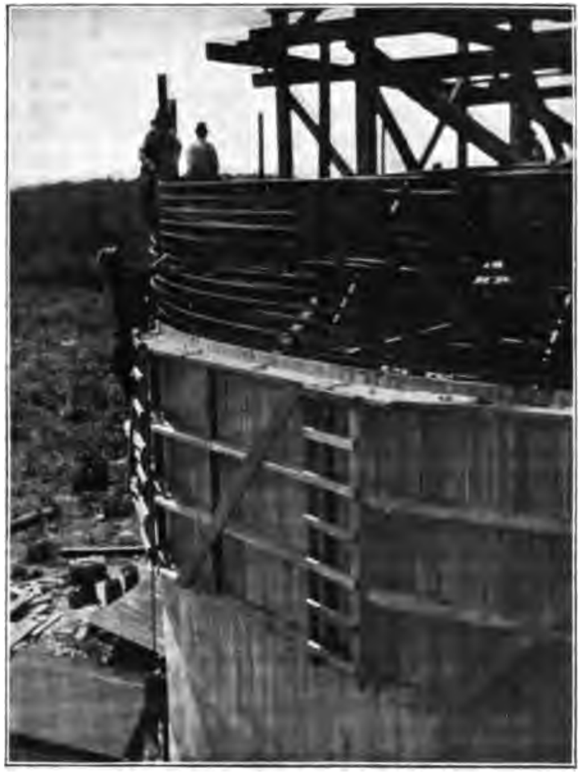

FIG. 2. OUTSIDE FORMS AND STEEL REINFORCEMENT.

throwing it a distance of four or five feet to insure the filling of the voids. This process was continued until the cement covered the entire outer surface so that further plastering could be perfectly bonded; on this surface was placed expanded metal, forced over the clips that stood out horizontally, and then a coat of plaster was carefully troweled over the surface of this metal, and then a coat of metal placed outside of that plastering, the ends of the clips being turned at right angles to hold the same in place. After this the final outside coat was applied, thus making a very firm and compact surface equal to any part of the structure.

After noting the result of the interior plastering, we were satisfied that some other method must be used to make the standpipe perfectly tight under one hundred feet head, at the same time realizing that in a warmer climate we should not hesitate to accept it as it was.

Upon consulting with our engineer and contractor we decided to coat the inside with what is known as the " Sylvester process " wash. I presume many of you are familiar with the same, but for the benefit of those who are not, I will give the formula used on this standpipe:

Dissolve ¾-pound Castile soap in 1 gallon of water. Dissolve 1 pound pure alum in 8 gallons of water. Both must be thoroughly dissolved. Before applying to the walls the surface must be perfectly clean and dry; temperature must be about 50° F. First, apply soap at boiling temperature with a flat brush, taking care not to form a froth. Wait twenty-four hours so that the solution will become dry and hard upon the walls, then apply the alum in the same way, at a temperature of 60 to 70° F. Wait twenty-four hours, and repeat with alternate coats of soap and alum.

On the Croton work, four coats of each solution rendered the wall impervious. According to the report made by Mr. Dearborn, a pound of soap will cover about 37 square feet, and 1 pound of alum will cover about 95 square feet. Water may be admitted to the tank as soon as the last coat becomes hard and dry.

This solution has been used with good success on a number of reservoirs, not exceeding a forty-foot head, making them absolutely tight.

In order to test this process we decided to try 35 feet of our standpipe from the bottom up. After applying four coats of the mixture we filled the standpipe full and at 100 feet head we found there were only four leaks in the 35 feet coated. On account of this success, we decided to apply four coats more to this same surface, that making eight coats from the bottom up to 35 feet, and above that distance, four coats; this is not yet completed, but will be within a few days.

There has been no time since the beginning of the structure that the commissioners or engineer have believed that we made a mistake in adopting this type of structure, and we sincerely hope that others will be benefited by our experience.

In closing I will say that I am thoroughly in favor of this type of structure. In constructing a receptacle for water, whether it be a jug or a reservoir, it is a natural desire to build it of stone or masonry. Somehow water tastes better, keeps cooler and cleaner, and the idea of holding water in a masonry structure seems altogether fitting. The aqueducts of Rome were of stone, and it was not until we came to handle water under pressure that metal came into use.

I believe that Attleborough may congratulate itself on its water system, the quality and quantity of the source of supply; in the use of the meter system and the resulting low consumption; in the possession of new cast-iron mains and the small loss of water by leakage; and in the acquirement of a storage reservoir second to none in the world, making possible, in connection with the new pipe lines, a system of fire protection which should and must impress the insurance underwriters to our financial betterment.

DISCUSSION.

Mr. Frank A. Barbour.* I regret that my engagements have prevented the preparation of an adequate discussion of the structure under consideration this evening. However, as you have already listened to the interesting paper of Mr. Snell, and as Mr. Wason, of the Aberthaw Construction Company, is to follow me, it is probable that anything I might have said will be well covered.

The use of reinforced concrete for the Attleborough tank was

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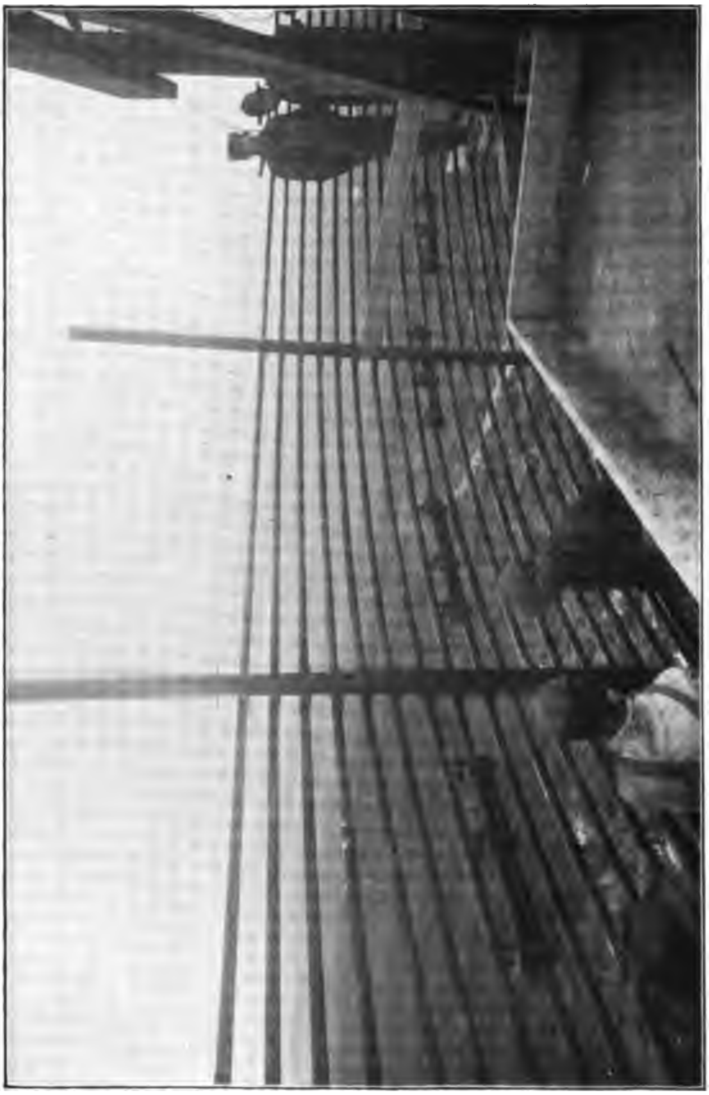
* Civil Engineer, Boston, Mass.

PLATE III.



STEEL REINFORCEMENT SIXTY-FIVE FEET FROM GROUND.

adopted because of the character of the water, which rapidly attacks steel; because of the large size of the tank desired; because of the greater artistic possibilities inherent in a concrete structure; and because of the lesser first cost and cost of maintenance over that of a steel tank.

With the desire to limit the bidders to specialists in reinforced concrete work, and to permit each bidder to use his special type of reinforcement as appeared to him to be necessary and in the best way, bidders were required to submit detailed plans and specifications of the system of reinforcement, the method of construction, and the waterproofing, and to guarantee the structure, in point of safety and watertightness, under penalty of a bond of $10 000, for the term of one year after date of acceptance.

General plans, showing the outward appearance of the tank, the pipe connections and the gatehouse, and general specifications, were prepared by the engineer. Section 4 of these specifications reads as follows:

> " And the general intention of these specifications is to specify the size, outward appearance, and the quality of the material and method of its incorporation in the work in so far as the material may affect the life of the standpipe beyond the period for which the contractor is held responsible; — leaving to the contractor the detailed design and choice of type of steel reinforcement, and requiring him to guarantee the safety of the structure and the absence of leakage for the term of one year.
>
> " It is the intention of the Water Board to consider proposals on the basis of cost and on the relative value of the bids as presented from the standpoints of strength and probable absence of leakage as indicated by the specifications describing the proposed method of construction as submitted by the bidder."

The general specifications describe the quality of the cement which should be used, requiring a tensile strength of 185 pounds in twenty-four hours, 600 pounds in seven days, and 175 pounds in 7 days when mixed one part cement, three parts sand, together with the further requirement that the cement mixed one part cement and three parts sand shall develop a strength in twenty-eight days 15 per cent. in excess of that shown in seven days. Fineness was to be such that not more than 5 per cent. would be retained on a sieve with 100 meshes per inch, and not more than

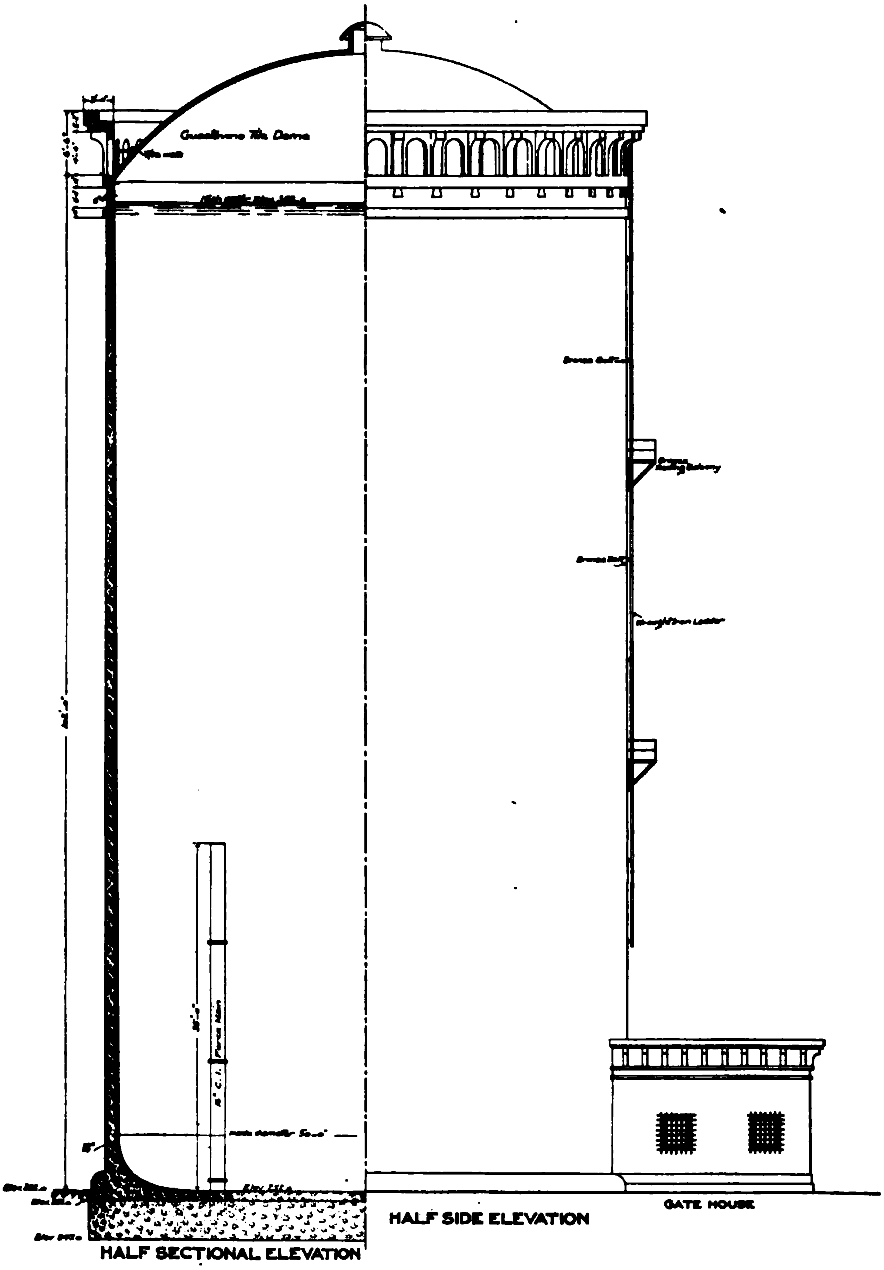
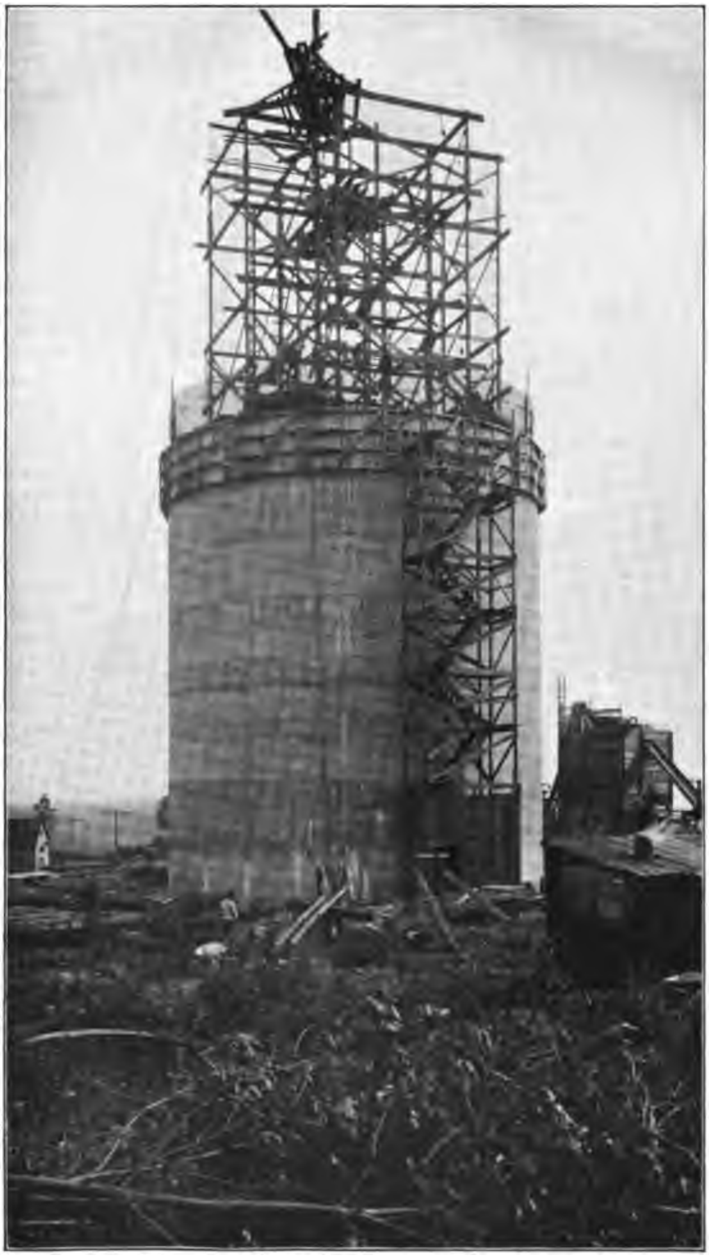


FIG. 1. ATTLEBOROUGH STANDPIPE.



STANDPIPE PARTLY BUILT.

24 per cent. on a sieve with 200 meshes per inch. The standard tests for soundness included the cold test and also the accelerated test in boiling water for three hours.

Five bids were received, the total price ranging from $33 679 to $75 000.

As a matter of interest showing various tests in regard to reinforcement, mixture of concrete, and method of waterproofing, it may be worth while to briefly summarize the different propositions.

The lowest bid involved the use of 1¼ by ¼ inch T-bars as the horizontal reinforcement, with vertical bars 18 inches apart in the walls; no steel in the bottom; horizontal reinforcement with a working stress of 13 000 pounds to 19 000 pounds per inch; bottom to be constructed of concrete, sides of cement mortar, mixed one part cement and three parts sand; horizontal rods joined by soft wire but principal reliance on the bonding of the concrete. Inside plastered with one-half inch coat one part cement, one part sand, and one-half part lime paste.

The bid of the Aberthaw Construction Company was based on the use of square, cold-twisted bars, from ¼ inch to 1¼ inches in dimensions, the working stress varying from 13 500 pounds per square inch at the bottom to 8 000 pounds per square inch at the top; the horizontal bars being placed in three rows at the bottom, two rows half way up, and one row at the top; ⅝-inch square bars being used vertically, 3 feet apart; grill work of steel in bottom for temperature strains; foundations to be constructed of one part cement, three parts sand, and six parts stone. The waterproof work was to be mixed one part cement, two parts sand, and four parts stone, or so as to give an excess of 10 per cent. cement over voids in sand. Inside surface was to be plastered with a special mixture of cement, sand, glue, and alum.

Another bid was based on the use of Thatcher corrugated bars, ¼ inch to 1¼ inches in dimensions, this reinforcement being used with a working stress of 15 600 pounds per square inch. Vertical bars ⅝ inches in dimensions were to be spaced 9 inches apart for 80 feet up, and 18 inches apart for the remainder of the height of the tank. Concrete in walls was to be mixed one part cement, two and one-half parts sand, and four and one-half parts stone; no plastering was proposed for walls, but the use of castile soap

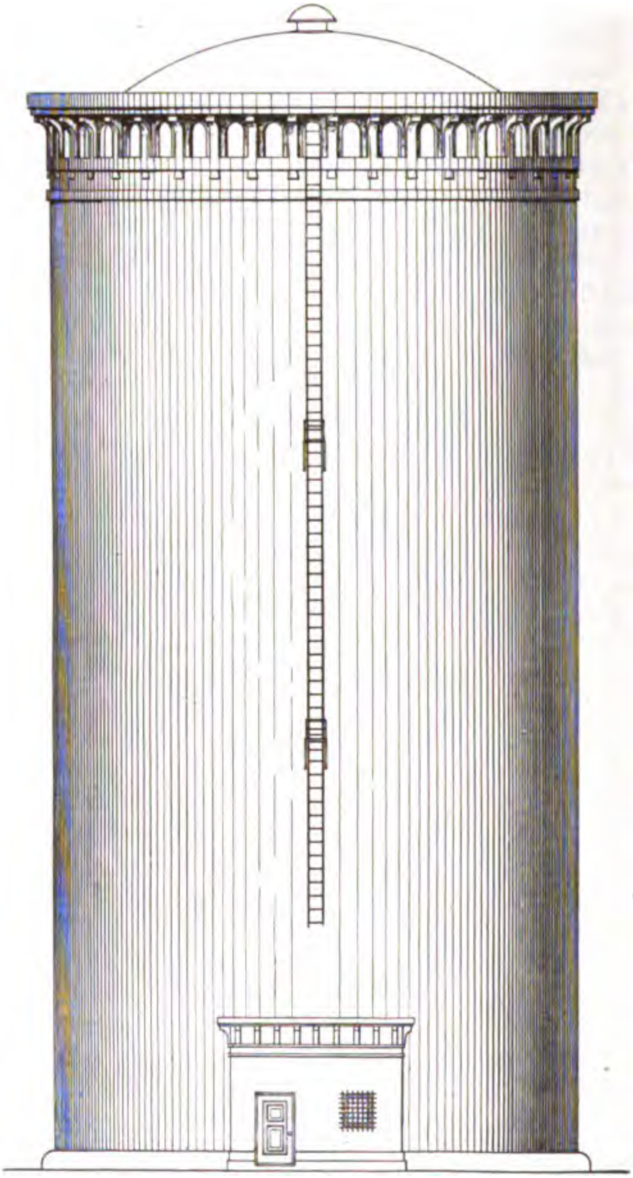
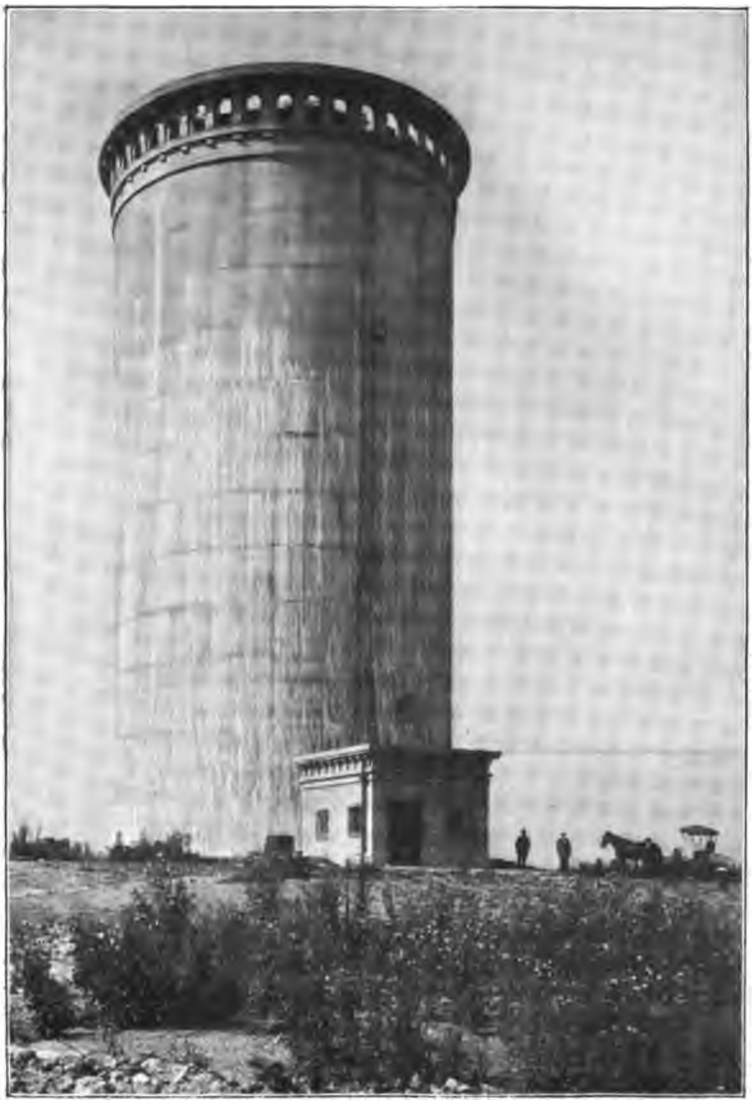


FIG. 2. ATTLEBOROUGH STANDPIPE.



COMPLETED STANDPIPE.

and alum, applied in three coats, was to be given wall after completion.

A fourth bid contemplated the reinforcement of the tank by Johnson corrugated bars, ⅝ inches to 1¼ inches in dimensions, used with a working stress of 15 800 pounds per square inch; vertical bars, ½ inch square, placed 12 inches apart; concrete in bottom, mixed one part cement, three parts sand, and seven and one-half parts stone; concrete in walls, one part cement, two parts sand, and four parts stone. The noticeable feature of this proposal was the inside and outside facing of the concrete walls with a course of brick, and the placing of a layer of waterproofing between the inner brickwork and the concrete.

The fifth bid proposed a mixture of one part cement, one and one-half parts sand, and three parts stone for the first 50 feet, and one part cement, two parts sand, and four parts stone for the rest of the wall. The reinforcement of Thatcher bars was to be used with a working stress of 14 000 to 19 000 pounds per square inch; plaster to consist of two and one-half coats 1 to 1 mortar, containing soap and alum, and a coating, consisting of lye, alum, and cement, was proposed for the waterproofing of the tank.

It is interesting to note that the working stress varied from 13 500 to 19 000 pounds per square inch; that the concrete varied from a mixture of 1, 2½, 5, to a mortar of one part cement to three parts sand, and that the waterproofing in all cases contemplated some method of surface treatment on the interior face of the wall.

The bid of the Aberthaw Construction Company was accepted.

Briefly, the structure is 50 feet in diameter, 106 feet high from the elevation of inside of bottom of tank to the top of cornice, with walls 18 inches thick at the bottom and 8 inches thick at the top, and covered with a Gustavino tile roof.

The inlet pipe rises to an elevation 40 feet above the bottom of the tank; check valves compel the water to enter through this pipe and leave through the 24-inch pipe at the bottom of the tank, thus insuring circulation. Below the cornice, ornamental pendants of concrete are placed, just above a belt course, and back of these pendants openings were made in the wall, thus providing a large number of spaces for the overflow of water in case of accident, this water hitting the back of the pendant, striking the belt course, and then falling in a spray to the ground below, thus preventing any danger of accident by washing such as might occur if the overflow were limited to one place. The gatehouse contains two electrically operated gates, by which the standpipe may be cut out and direct service obtained from the pumping station to the town.

The soil foundation was an excellent quality of hard pan and bowlders.

Describing first the material in the work — the cement was Atlas, especially fine ground, as shown in the following result of tests, for which samples were taken from one barrel in fifteen:

	Tensile Strength.					Condition of Pat Test.		Fineness.	
	Neat.			1 Part Cement. 3 Parts Sand.		3 hrs. in Steam.	28 d. in Water.	Percentage Retained on	
								200 Mesh Sieve.	100 Mesh.
	24 hrs.	7 d.	28 d.	7 d.	28 d.				
Average,	373	594	689	266	358	Perfect		14.5	1.0
Maximum,	474	697	793	339	422			15.8	1.8
Minimum,	203	478	582	199	281			12.3	.5

The sand used was obtained locally, and had on the average an effective size equal to .30 millimeter, with a uniformity coefficient of 5.6. The stone used, for the most part taken from the immediate vicinity of the work, was of excellent quality, with an average specific gravity of about 2.68. The stone was crushed and passed through screens with openings varying from ¼ inch to 1½ inches diameter. Immediately below the crusher three bins were placed from which the material could be fed directly into a Smith concrete mixer. The material passing the finest screen was discharged into a sand bin, the medium-sized stone into the second bin, and the coarse stone into the third bin.

Mechanical analyses of the sand and aggregate were made daily, and the material combined so as to reduce the voids to a minimum.

Considerable information, too detailed for presentation in this paper, was obtained in regard to the value of these mechanical analyses. In this connection it should be stated that while such analyses well justify the expense, all the good results of a proper mixture can be readily discounted in the placing of the concrete. Separation of the aggregate will, to some extent, occur in the discharge of most mechanical mixers, and the final character of the concrete for waterproof work is determined by the maintenance of a thorough mixture up to the actual placing of the concrete in the walls, and the required degree of care in ramming and " joggling " the material to place in and around the walls.

As already stated, it was intended to use square twisted bars, but the impossibility of bending these in a plane necessitated the adoption of some other form, and circular bars of .40 carbon steel, with an elastic limit of 50 000 pounds and an ultimate strength of 80 000 pounds per square inch, were finally adopted. It was also decided to use 1½ inch bars in two rows at the bottom of the wall, instead of the smaller steel bars in three rows, so as to facilitate the placing of the concrete. The steel was delivered in lengths of 56½ feet, three lengths with a lap of 30 inches at the ends making a complete ring.

The use of this .40 carbon steel and the consequent difficulty in bending and holding the bars to the proper circle constituted one of the principal difficulties in the construction of the work. This steel could not be bent in the work and it had to be passed through rolls, which did not, in all cases, develop the true curve out to the extreme ends.

The placing of the steel was begun using the ⅝-inch twisted vertical bars as originally planned. It was soon ascertained that in order to maintain the horizontal reinforcement in proper alignment and with the desired vertical spacing, some other method of supporting these members would have to be adopted, and it was determined to use channels, fifteen in the circle of the tank, with the web placed radially and the flanges drilled at proper intervals for the reception of short lengths of ½-inch bars, on which the horizontal reinforcement was hung inside and outside of the channels. In this way the vertical and horizontal spacings of the horizontal reinforcement was insured.

With this method considerable difficulty was encountered in maintaining the 1½-inch bars in alignment, and the work would have been facilitated had additional channels been used. The use of the .40 carbon steel was responsible for this difficulty, and had a softer steel been employed in the work, the erection of the tank would have been rendered much more simple and the final results more satisfactory. This will be referred to later in my remarks.

The regular routine in construction of walls was, first, the erection of the steel for a height of about seven feet or the depth of the form; then the placing of the inside and outside forms; then the filling of the forms with concrete; then a cessation of the work to allow the concrete to set preceding the erection of additional steel. It will be noted that this schedule necessitated a considerable interval between the placing of the different layers of concrete. The feasibility of insisting on the continuous placing of the concrete was one of the debatable considerations in the early days of the work, and one contractor proposed to follow this scheme. Experience, however, early proved the impracticability of continuously placing the concrete in a tank of this size. In smaller structures where a complete outside form can economically be erected to the full height in advance of the work and ribs for the inside form provided, so as to permit the rapid placing of lagging as the work progresses, then it may be possible to place the concrete continuously. In a tank such as that under discussion, the forms must be sectional and the steel must be supported by the concrete as it is erected. This means a cessation of the concrete work between the moving and erection of the forms and steel, which cannot be avoided. By inserting beveled tonguing pieces and by thoroughly washing the joint so as to remove all dirt and laitance, and by covering the joint with a layer of thin grout and mortar before placing additional concrete, watertight joints can be obtained. This was proved, as practically no leakage has occurred at any of the joints.

It cannot be too strongly emphasized that the final outcome in a structure of this kind depends upon the proper placing of the concrete and the maintenance of a uniform mixture up to the actual point of its being deposited in the wall. Success depends not only on an appreciation by the contractor of the necessary character of the work, but also by the workmen. With a mechanical mixer preparing concrete rapidly and a derrick raising it to the platforms from which it is shoveled into the forms, despite the fact that there were usually a tamper and spader to each shoveler, it was found that in certain places imperfect work would occur. These places were principally in evidence during the first few days of the work, and the quality of the concrete grew rapidly better with the acquired experience of the workmen. In several instances a mixture somewhat too wet was used, with the result that the spading and ramming served to drive the stone to the bottom of the batch being placed, with the result that in these places porous spots occurred. It was clearly proven that a mixture no more wet than would at all times support the aggregate was desirable. Placing concrete in a thin wall with a large part of the section occupied by two rings of steel bars calls attention to the possibility of the stone wedging in and around the bars in such a way as to prevent easy filling of the entire space. For this reason it is believed that round bars are better than square bars because of the greater ease with which the concrete will fill underneath them. In this connection, also, the advisability of using a thicker wall is worthy of consideration. On the other hand, with a thicker wall, certain sections of the concrete must be at a greater distance from the steel reinforcement and such sections, in case of deformation of the steel under tension, may lose the effect of the adhesion between the concrete and the steel, with a consequent cracking of the surface.

In this connection, also, the advisability of using a mortar or a mixture of sand and cement without stone, because of the greater ease and certainty with which it can be placed, may, perhaps, justify the resulting increased expense. It is estimated that, in the tank under discussion, if a mixture of 1 to 2 mortar had been used instead of the 1–2–4 concrete, the cost would have been increased $2 300; with a 1 to 2½ mortar, $1 500; and with a 1 to 3 mortar, $750. This extra expenditure in a structure costing $35 000 may, perhaps, be justifiable in the decreased liability of imperfect concrete and the greater certainty of an absolute bond between the steel and the cement.

When the walls had reached a height of twenty feet, the tank was filled with water to the elevation of the bottom of the lower form. A considerable leakage at once developed. By plastering the wall, digging out the spots of obviously pervious concrete, the percolation was considerably decreased, but these spots of poor concrete have, until recently, always been more or less in evidence.

I do not intend to enter into a detailed description of the methods used in construction except so far as to explain certain suggestions which I believe may be adopted in future work.

Immediately on the completion of the foundation a hard pine tower was constructed on the interior of the standpipe to an elevation of sixty feet, and on this tower a derrick was erected and maintained at this elevation until the tank was raised to the top of this tower. The tower was then carried up to an elevation of about one hundred and ten feet, and the derrick again raised. This tower was entirely independent of the walls, and served merely to support the derrick and dumping platforms from which the concrete was shoveled into the forms. The existence of this independent structure was unquestionably of advantage in handling the materials, both concrete and steel. The tower, including the raising of the derrick, cost about $1 700.

Outside forms made in sixteen sections, about seven feet high, with horizontal ribs and vertical lagging, and locked together by clamps on the ribs, were provided in two sets, one above the other, the lower one being loosened and placed above the other as the wall progressed upward. These forms were held in place solely by the binding effect of the clamps and the consequent friction on the completed wall. The interior forms were constructed of ribs on which horizontal straight lagging was laid during the progress of placing the concrete, in order to give the spaders a better opportunity to work between the steel rods. The forms were not as heavy as is desirable, and should have been provided with more diagonal bracing and better means of connection and clamping at the ends. The batter which was given the outside of tank increased the difficulty in handling the outside forms, which had to be adjusted from time to time to the varying circumference. It is questionable whether the added effect given by this batter justified the increased difficulty in handling the forms. It is also believed that it would have paid to cover the outside forms with sheet metal.

One of the conditions to be strenuously avoided in the construction of a concrete structure similar to that under discussion is the possibility of either the steel or the concrete moving after the concrete has been placed and partially set, so as to follow the movement of either the steel or form. With the high carbon steel used in the Attleborough tank and the difficulty of maintaining it in place without the rings being under some stress during the filling of the forms with concrete, it seemed impossible to avoid the chance that some movement of this steel might take place which would result in the formation of a void in the concrete wall. This was also true of the sectional forms. Thus, despite the fact that with each moving of the lower set of forms upward on the wall the circle was carefully taken by steel tape from a center wire on a heavy plumb bob from an independent tower in the center of the tank, it would frequently be found that the forms had moved a fraction of an inch during the placing of the concrete.

It may be worth while to refer to the clips which were used in tying the ends of the steel bars together. These were of the Crosby type, three being placed at each joint. Aside from the increased bond thereby assured, they were necessary with the steel used by the Aberthaw Company in order to tie the ends together and hold them in place during the filling of the forms with concrete. Without these clips the wall never could have been erected. Joints put together on the work, and tested at Watertown Arsenal, proved that the three clips developed the working stress of the steel. As the clips failed by tipping, it is believed that, allowing for the supporting effect of the concrete, the joints in the work will develop the elastic limit of the steel.

As a matter of interest it may be stated that the 1-2-4 concrete in walls cost, approximately, as follows:

COST OF CONCRETE IN WALLS.

	Per Cubic Yard.
Cement	$4.80
Sand and stone	3.90
Mixing concrete	.40
Placing concrete	2.20
Form work	2.65
Total	$13.95

Bending and placing steel cost about $9 per ton, or $2.30 per cubic yard of concrete. There were 770 cubic yards of concrete in the walls, and about 185 tons of steel. The clips, of which about 3 000 were used, cost $1 100.

The work of placing the concrete in the walls, because of various reasons, progressed slowly, and the cornice was not completed until after October 1, 1905. After this the tile roof was constructed, with the consequence that plastering the interior surface was not begun before cold weather had set in. It was attempted to heat the interior so as to permit the completion of this work, but it was found to be impracticable. By agreement with the contractor, the town concluded to use the structure throughout the winter, despite the fact that from the beginning of construction more or less leakage had been in evidence. The principal reason for concluding to keep the structure full of water was the hope that, with use, the leakage would decrease by precipitation of the carbonates in the voids of the concrete. This action has always been in evidence, and frequently leaks will absolutely stop and then apparently, by the breaking of this carbonate dam, subsequently open. It is to be noted that at no time, so far as the amount of water loss is concerned, have the leaks been serious, and if the standpipe were located where freezing weather did not occur, the structure would have been satisfactory even in the condition under which it was used last winter.

The use of the standpipe developed, in certain places, along towards spring, spots of several square feet in area which scaled off the exterior surface, apparently being thrown out by pockets of water which had collected, frozen and expanded. These pockets were unquestionably due to the movement of the steel or forms during construction at a time sufficiently long after the placing of the concrete so that some set had occurred. This scaling of the exterior surface was confined to areas in the lower fifteen to eighteen feet of the tank. No additional leakage developed, and in all cases the concrete tank, other than these scaled areas, remained in excellent condition.

With the return of spring, the Aberthaw Construction Company undertook the completion of the work, repairing the defacement of the outer surface and plastering the inside. The result has been that, with the completion of the plastering, details of which will, presumably, be given by Mr. Wason, the leakage was decreased to practically a sweating in a limited number of spots. Since then a number of alternate coats of castile soap and alum have been applied, with the consequence that, at the time of last observation made by the speaker, there was no sign of any leakage except in one spot about a foot square, where there was a slight sweating.

The working stress in the steel varies from 8 000 to 13 500 pounds per square inch. At the highest limit the maximum deformation in the steel, due to water pressure, will be about .43 of an inch in the semi-circumference. The adhesion between the steel and the concrete, which is many times in excess of the working tensile stress, prevents movement of the concrete on the steel, but at the surface section most distant from the reinforcement minute cracks have developed, invisible when the wall is dry and only to be found as the tank is drying out or in the manner used by Professor Turneaure in testing beams. This suggests the possible advisability of distributing the reinforcement so as to bring it as near the inside surface of the tank as possible, in such a way that the interior section will partake of the adhesion between steel and concrete. On the other hand, there are some reasons for concentrating the steel as nearly as possible in one plane in order to make certain that all rods are brought under tension uniformly.

As all steel structures economically designed must be based on some deformation, and as in this case the elastic reinforcement is surrounded by a particularly inelastic medium, it would appear that, except so far as the adhesion of the steel and the concrete will counteract the results of stretch in the structure, water-tightness must be obtained by some elastic coating which will cover the minute checking of the surface. It is, of course, unnecessary to state that these cracks are absolutely microscopic and entirely invisible except as indicated by the narrow wet streak which remains after the tank has practically dried out. It has been suggested that, by adding lime or soap to the concrete, the concrete might be made more waterproof: It is questionable whether this would prevent the checking of the surface, and unless it is possible to use steel with such stress as to bring the structure within the elastic limits of the concrete, waterproofing under higher heads must be obtained by an elastic skin coat. This coat the Sylvester process is apparently able to provide.

Another feature in the design of a structure of this type is the reinforcement connection between bottom and sides. This involves another form of the old problem of an arched dam. With a working stress which will make such a reinforced tank economically possible there will be some stretch in the steel — the bottom is, of course, under compression alone. It would, therefore, seem that radial reinforcement of the bottom running up through the connecting fillet and well into the sides is worthy of consideration.

The above discussion has been intended to call particular attention to the incidental difficulties encountered in the building of the reinforced standpipe. This has been done with the feeling that, in a new field of this kind, by this way alone can progress be made. Because particular attention has been paid to the difficulties encountered and to the possible improvements in future design, the conclusion should not be drawn that the structure is not a success. The engineer, the contractor, and the authorities at Attleborough, have always been perfectly satisfied that no mistake has been made in adopting this type of reservoir.

Summing up the results of experience, it would appear that a soft steel should be used, distributed so as to permit as much greater section of the steel to partake of the effects of adhesion as possible; that extreme care must be taken to prevent movement of the forms and steel during the placing of the concrete; and that in all probability the greater ease and surety of absolutely filling the voids will justify the use of a mixture of cement and sand alone or, perhaps, with fine, clean, screened gravel added, the primary endeavor to be to make the body as a whole as homogeneous and impervious as possible, trusting for final waterproofing to a fine coating of some elastic preparation, the necessary attributes of which are apparently fulfilled by the so-called Sylvester process.

Mr. Leonard C. Wason.* Previous to bidding on the reinforced concrete standpipe at Attleborough, Mass., the writer had built a number of watertight cellars, six swimming tanks, and quite a number of cement tanks for various purposes. Most of these were waterproofed entirely in concrete. The greatest head of water in any of them, however, was ten feet. From this experience the writer saw no difficulty in constructing a tank to hold one hundred feet, and subsequent experience has not changed this view.

The specifications and plans were left open for the bidders to design the reinforcement and suggest the mixture of the concrete. In addition to the hydrostatic pressure, allowance was made for ice. By reference to Trautwine's "Handbook," the writer found the maximum theoretical ice pressure would burst the strongest steel tank ever built, and he, therefore, arbitrarily assumed a tension from ice of 30 000 pounds per foot of height on the concrete from top to bottom. The steel was designed for a maximum tension of 18 000 pounds per square inch, of which 13 500 pounds was due to water, the balance to the assumed ice pressure.

Subsequent experience would indicate that there is no trouble from ice, and, therefore, the maximum stress is that due to water only.

As the result of an elaborate series of experiments carried on by the Metropolitan Water Board at Clinton, confirmed by others, and also by the writer's own experiments and experience, it has been determined that mortar made of 1 cement, 2 sand is impervious to water; and concrete approximating 1–2–4, but with from 5 to 10 per cent. excess of mortar over the voids in the stone, would also be waterproof. These were the mixtures that were used, and they proved very nearly waterproof. In selecting material, the writer desired to use gravel screenings, but as none were available, and as there was a large quantity of hard stone in the immediate vicinity, broken stone was used. A good quality of clean, coarse, sharp sand was obtained nearby. Atlas Portland cement was used throughout. A careful mechanical analysis of the sand and stone was made daily in order to get as well-graded sizes of materials, and, therefore, as dense concrete as was possible.

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*President Aberthaw Construction Company, Boston Mass.

In the design as finally executed the steel reinforcement consisted of 1½-inch diameter plain round bars in two rings from the bottom to a height of 60 feet. Above this a single row of steel was used, which, at 81 feet, was reduced to 1⅛-inch diameter. There were 2½ inches of concrete outside of the outer ring, and 4 inches between, so as to give freedom in placing concrete; and the spacing of the bars vertically increased with their height above bottom from 3¾ inches to 8 inches, corresponding with the reduced pressure from water. They were about 56½ feet in length, so that three made a complete ring, and were united at the ends with three Crosby guy-rope clips on a splice of at least 30 inches. They were supported rigidly in place by fifteen vertical 4-inch channels with pins passing through holes punched in their flanges at the spacing on plans, thus giving the exact spacing desired. Each splice was advanced 5 feet over that on the adjoining bars, so that no two splices in either ring came in line; and in one vertical plane there was but one splice in eleven bars.

After the tank was completed a coat of plaster was applied to the inside by the same workmen who had done the concrete. These men were not skilled in plastering.

The plant consisted of a horizontal boiler with engine mounted on its back, driving a Sturtevant roll jaw crusher, which crushes all stone to the size of 1 inch or smaller; elevator, rotary screen, and bins from which stone was drawn into a measuring hopper and fed into a Smith concrete mixer. A circular and band saw were also attached to engine. A heavy tower of hard pine was built in the center of tank, on top of which was a derrick with 40-foot boom handled by engine on the ground, which also had a revolving gear attached. The steel bars were bent by being pulled through a tire bender around a curved form by a steam engine.

The soil gave an exceptionally good bearing. Trenches were excavated below frost line, the pipes laid and embedded in the concrete mixed 1–3–6. This included 18-inch thickness over the entire area of tank. Upon this base the waterproof concrete of tank began. The floor and a portion of wall about 2½ feet high was cast at one continuous operation in order to avoid all seams and joint. This floor was 1 foot thick and was finished with granolithic troweled on as an integral part of the construction, and reinforced with ¼-inch twisted steel bars 6 inches on centers in both directions near the surface in order to resist shrinkage cracks. Quite a number of bars were also embedded in the floor radially and turned up in the wall to bond the two rigidly together.

After completing the floor the tower and derrick were erected; steel was set to a height of 7½ feet, and wooden forms, which were 7½ feet high, made in sections about 11 feet long, were erected. The outer forms were lagged vertically; the inner ones were lagged horizontally, one board at a time, while wall was being filled, so that the concrete was always accessible while being placed. When placing concrete, the work was done in four places around the circumference at once, and as rapidly as possible so as to obtain monolithic work, the entire circumference being kept at uniform height, and the 7½ feet being filled before stopping. At the top a strip of beveled 2-inch by 3-inch wood was put in the middle of wall to form a groove. Before again placing concrete, the top surface was thoroughly scrubbed with water to wash away all laitance, and then the groove and top of the wall was completely coated with neat cement. This joint proved very effective. The operation of placing steel and raising forms took three days, so that the surface on which concrete was placed was quite hard when the work of placing was resumed.

Leakage, etc. — Water was admitted to the tank as it rose in height, the water being kept about twenty feet below the working surface. Numerous small leaks developed, but only two were of sufficient size to squirt beyond the face of wall. From personal observation and cross examination of every one interested in the construction, the writer has been unable to learn that any leak appeared at a high head which did not appear first at a low head. The quantity leaking in some cases increased with the head. The total volume of water lost was small and decreased with time, the leaks appearing to silt up. Were it not for frost they would not be worthy of consideration. In but three or four places was there any indication by discoloration on the surface that the leakage had rusted the iron. On account of frost, it is objectionable to have walls so saturated with water, as it might lodge in pockets and spall off the surface. This actually occurred in some places last winter. Where there were leaks a white substance was washed to the surface and deposited. By chemical analysis this proved to be almost entirely calcium carbonate, together with some calcium hydrate. This indicates simply that free lime was leached out of the cement. After the plastering was completed on the inside, water was almost immediately admitted, and when drained out, some months later, a deposit of muddy appearance was found on the bottom of tank. This, by analysis, was found to be iron, alumina, sand, and calcium hydrate; it was decomposed cement from which most of the alkali had been removed, doubtless due to water being admitted too soon.

The first coating of plaster was not successful in stopping the leaks. The tank, nevertheless, was put into service and became nearly tight. Last spring it was replastered in a most thorough and careful manner, in the lower twenty feet five coats being used, but with no better result. Subsequently, Sylvester solution has been applied as follows: Thoroughly clean and dry the wall; then a pure Castile olive-oil soap solution was used, 12 ounces to one gallon of water, applied boiling hot. Twenty-four hours later, when the wall was dry, a solution of alum (2 ounces to a gallon of water) was applied at the normal atmospheric temperature; soap and alum washes alternated for four coats of each. This is the method used on the Croton reservoir to waterproof brick walls in 1870. The result, although not perfect, was very encouraging, and four additional coats have been applied, the work not being yet finished. The last time the writer visited the tank, with fifty feet of water, there was but one leak, and this produced only a wet spot the size of the hand.

As a result of this work, the writer believes that the success of this type of construction has been proved. While every means and all information that the present state of the art yielded were availed of, still from the experience gained some further improvements can be made. For instance, a low working stress should be used in the steel to avoid cracking the cement, and soft steel should be used instead of medium hard; also a change in the number and arrangement of bars. Some improvement could be made in forms to avoid possibility of movement of concrete after being placed while setting which would cause porosity around the reinforcement. A little stronger mortar and less stone could be used to good advantage; and some changes in mechanical plant could be made in connection with the above changes which would simplify the work of erection.

Using a working stress of 13 500 pounds in the steel and a modulus of 30 000 000 pounds, the stretch in semi-circumference of 81 feet when tank is full of water would be .444 inch. It would seem that concrete could stretch this much without cracking, but experience has shown otherwise, as twenty-four hours after water is drawn from the tank, when the walls are drying, so-called " water cracks " show: fine vertical dark lines, with a few horizontal, which indicate that the surface of the cement has been cracked. They are invisible when wall is dry. The plaster coat cracked directly over the cracks in the wall. This would indicate that concrete is an exceedingly rigid and inelastic material. An elastic material is used to bind together a brittle material that will crack at one tenth the stretch steel has at its elastic limit. This is the serious problem of standpipe design. If enough steel is used to prevent cracks, its cost is prohibitive; if a less amount is used, the concrete cracks and leaks. Therefore, as a compromise, use a low stress in steel and an elastic waterproof skin on the inside. The coat of Sylvester solution appears to be sufficiently elastic to form a watertight skin which would stretch without cracking and thus produce the desired result. With the experience in the construction of this tank and a few others which have been built, the art will soon be so perfected as to make this type of construction safe and sane for all locations. In cost such construction can compete for large tanks, but not for small ones.

Lastly, a necessary element of success is to let this type of work only to contractors with large experience, who will appreciate the difficulties and have the technical knowledge and a conscientious desire to master them.

PUMPING WITHOUT ATTENDANCE.

BY S. A. AGNEW, SUPERINTENDENT SCITUATE WATER WORKS, NORTH SCITUATE, MASS.

[*Read September 13, 1906.*]

When I came to read the title that I gave to the troubles that I have endured at my pumping station for the past five years, it struck me as rather a bold title and not very far from misleading; for really, there is no machine that requires closer and more exacting attention than the so-called automatic machine; and particularly is this so of the internal combustion engine, whether it use gas, gasolene, kerosene or what not; for the slightest disarrangement of any of its parts, or the least obstruction to its ignition, or to its flow of gas, throws the whole machine out, and before you can say " Jack Robinson " your engine has slowed down and stopped; and then you have a grand good chance to get to work and get all covered with grease and dirt, finding out your trouble, and one of the best opportunities in the world to exercise the God-given virtue of patience in getting your engine started again.

However, Mr. Kent seemed to think you gentlemen didn't have troubles enough of your own, but must needs share mine, and so I will tell you some of them and then be ready to receive your congratulations — or commiseration — when I get through my story.

I don't suppose there is any call at this time to speak of the general principle of the gas engine; undoubtedly you are all familiar with it, or if not you will find the subject pretty thoroughly covered in the catalogues of the various engines; and as for their good points, just read a few of these circulars and booklets — or better, get hold of a salesman. But if you want to know what thoroughly tantalizing, "cussed " things they are — run them.

The works that I have to do with are comparatively small; we get our water from driven wells and pump into a standpipe on a hill about three quarters of a mile from the pumping station, and when the standpipe is full, we have about 175 feet head at the pump.

A most serious problem with us is the vacuum we pump against. We have a good supply of good water, but it comes hard and slow, and this summer our vacuum gage has registered as high as twenty-five inches.

We pump our water with two single-acting, triplex pumps (made by the Platt Iron Works), driven direct by two Hornsby-Ackroyd oil engines of sixteen horse-power each; that is, each pump of about a quarter of a million gallons capacity per day is operated by its own engine. And it is with the engine end of it, mostly, that Mr. Kent wishes me to deal to-day.

The great consideration in favor of this kind of engine is on the score of low cost of operating.

Under ordinary conditions these engines can be started by any ordinarily intelligent man; the pumping station can then be locked up, and the man go off about his work for the day, returning at night to shut down, or to oil up if the engine is to be run all night.

This I have done for the past five years; and while there are some drawbacks in such works as ours, where we have only a standpipe twenty-five feet in diameter and seventy-five feet high to pump into,— and unless the standpipe is kept pretty nearly full, people on the high hills get out of water, — still, for small works that can hardly afford an engineer at the pumping station all the time, it is a very cheap way and a very satisfactory way to pump water.

And now as to the engines themselves: The Hornsby-Ackroyd oil engine — the kind we use — is a very simple machine, with very few parts to get out of order; so simple, indeed, that one would suppose it couldn't get out of order. And yet, strange as it may seem, it does.

It is a four-cycle engine, of the hot-surface ignition type.

To start it, the vaporizing cap has to be heated by an ordinary coil lamp until it is hot enough to vaporize the charge of oil that is sprayed into the chamber, and after that the explosions in the vaporizer keep it sufficiently hot to vaporize the oil, without any outside help from the heater.

The engine manufacturers claim that these engines can be started in from five to ten minutes, and possibly they can if everything is in ideal condition; but I have found in practice that it really takes from twenty minutes to half a hour.

This is not all lost time, however, for it ordinarily requires that length of time to get the engine and pump oiled up and generally attended to. For you must know, that if a machine like this is to be left to run itself for hours at a time, and no one to see it, all the care and attention which the ordinary engine has bestowed upon it continuously has in this case to be crowded into the time when the engine is being started; and if this idea is not kept in mind, and any part is overlooked or only carelessly attended to, it is pretty sure to result disastrously.

This, I believe, is the all-important thing to impress on the mind of the man who runs one of these engines. And even after all the carefulness possible, there will things happen that no one can foresee.

For instance, one day I was driving down in the direction of the pumping station, and met an old Irish teamster who was working for me at that time. When the old man spied me coming, he got off his " jigger," and with his hands up to hail me and a look of terror on his face, shouted almost before I was within hearing, " Misther Agnew, dat engine ish goin' like hell." And sure enough, when I got to the station things did look and sound as though they were going in the direction the old man suggested.

A key that held the governor had worked out and the engine was racing. It was rather terrifying to go in and stop it amidst all the noise and clatter of the racing engine and pounding of the pump. But when it was done and the engine looked over carefully, no damage could be found — not even a warm bearing. And so the governor was fixed up and the engine started, apparently none the worse for its race.

And speaking of warm bearings· The greatest and most constant danger in this method of pumping is hot bearings.

Most of the pump bearings are designed to use grease, and on these we use a mixture I make up myself of Albany grease and graphite. Occasionally one of these bearings will warm up a little and the grease melting and running out faster than it ought gets thrown around by the revolving crank and everything around gets bespattered with that black grease. However, the cups are pretty large to allow for just such happenings, and so no bearing has ever been really damaged on the pump.

On the engine bearings, nothing but oil is used; and I never was fully satisfied with the different methods used for lubricating the different parts, so I have supplemented them with little devices of my own. And even now they are a constant source of anxiety to me, for the piston velocity is pretty high, and let anything occur to obstruct the proper drip, or let them drip too fast and so empty a cup, and there is sure to be something ruined.

There was another difficulty that caused me no end of annoyance at one time, though I am not troubled with it now. The engine made carbon in the vaporizer. It was the funniest thing, too, and I never had the satisfaction of knowing just why it did it, either. This carbon would form in loose balls from the size of a pea to the size of a hen's egg; and when about so much had formed the engine would cool down and stop. It was the most baffling thing with which I ever had to deal.

The engine has stopped as many as three times a day, and each time it stopped the vaporizer cap had to be taken off and the carbon removed — from a quart to two quarts of it. And then at times, for no apparent cause, the engine would run for weeks, and not deposit one particle of it, and then as suddenly begin again.

I did everything I could possibly think of, to remedy it; took the engine all apart, time after time, without any result; for the engine would seem to deposit this carbon just when it saw fit. I had men from the factory who were supposed to be experts, who did the same things I did, and did just about as much good; and the only satisfaction I could get from them (and their bills of expense) was, that the engine ought not to do it.

However, as I said, I don't have this trouble to contend with now, and the only reason I speak of it is because I understand there are members of the association who contemplate installing engines similar to these, and this is one of the troubles they may have.

Now these are some of the troubles I have had in the past. As to the advantages of this method of pumping, as I said before, the engine can be left entirely to itself, and if it is properly attended to when starting up, will need no attention whatever for ten or fifteen hours.

The time required to start my engine in the morning so that I can go through the day with a comparative feeling of security is about an hour. Say the machine is to run all night also, it will require about another hour in the evening to oil up.

Now, ordinarily, this is all; and you must know that this is not very much time to put on a machine for a twenty-four-hour run.

About twice a week the spray valve, a valve that sprays the oil into the vaporizer, ought to be taken out and thoroughly cleaned, and any dirt or obstruction removed; this takes about ten or fifteen minutes, and can be done generally while the engine is heating up, so that no extra time need be charged up on that account.

For the benefit of the association, I have made some accurate tests during the past month to ascertain the fuel cost of pumping with this kind of engine. Every bit of oil has been measured very carefully, and a close record kept of the hours and minutes the engine has run, and I might say that is the first time I ever attempted to make a really accurate test.

The fuel we use is a cheap fuel oil that can be bought in Boston for about 4½ or 5 cents per gallon in barrel lots. It can be bought considerably cheaper in tank cars and in some other places. I have bought it as low as 2¾ cents of an independent oil concern, but on account of increased transportation charges, it cost us about as much as oil bought in Boston at a higher price; and we can get it at shorter notice from Boston. So that for our works the most satisfactory place to purchase is in Boston.

By careful measurement, extending over a considerable period, I found the average consumption of oil to be 1.14 gallons per hour. The average head, including friction, was 180 feet. The amount of water pumped was calculated from the number of revolutions of the pump, and the average displacement per hour was 9 600 gallons, from which I took 5 per cent. for slip.

$$9\,600 - 5\% = 9\,120.$$

This divided by 1.14 gives 8 000 gallons of water pumped per gallon of oil consumed; or, with oil at 1 cent per gallon, the cost would be ⅛ of a cent per 1 000 gallons—from which you can see what the cost of pumping per 1 000 gallons would be, with any given price per gallon for oil. For instance, with oil at 4 cents per gallon, the cost would be ½ a cent per 1 000 gallons of water; at 6 cents per gallon, the cost would be ¾ of a cent per 1 000 gallons; at 8 cents per gallon, the cost would be 1 cent per 1 000 gallons, etc.

The above results put into foot pounds of water pumped per gallon of oil, give 12 031 200 foot pounds per gallon of oil.

I should like to say that in making these tests no special effort was made to secure favorable results or establish records of high efficiency, but rather to secure a record of everyday results. The engine was taken just as it was, and no effort whatever made to put it in better condition than it is every day. I might possibly have secured a higher efficiency had I prepared the engine for it, but it seemed to me that results secured under everyday conditions are of more practical use to us than those secured with conditions ideal, — a state of affairs that doesn't very often exist at most pumping stations.

The labor cost is very small indeed, — two hours per day would be a fair average; but for extras, add, say, 50 per cent. This would be three hours per day for attendance; and I can assure you that this three hours is a generous allowance. Furthermore, three hours will cover a twenty-four-hour run as well as a five- or ten-hour run. In fact, the nearer you can run the engine continuously, the less per hour it costs for attendance, for it takes a man about so long each time, and once the engine is started, it can run fifteen hours just as well as five hours.

That brings me to another thing I want to say right here, in regard to lessening the labor cost: There is a tank under each engine that holds about twenty gallons of oil. You can measure a certain amount of oil and put in this tank — say, 11½ gallons. Start the engine, and leave it, allowing the engine to run down when the oil is used up. This 11½ gallons will run my engine about ten hours. We see, then, there is no occasion for any one going near the pumping station from the time the engine is started one day until it is time for the engine to be started the following day, or whenever it is necessary to start up.

I have done this time and again, especially in the winter, when I have very little help, and so make a considerable saving in my labor bill.

There are other small items of expense to be added to the regular operating expenses, — grease, lubricating oil, etc. But these are small items, for the only new lubricating oil I use is on the piston of the engine. All the oil bearings are lubricated by old oil that has been cleaned in the filter, and if I find my second-hand oil accumulating too fast, I use a little of this on the piston.

Now, gentlemen, I don't know as there is very much more to be said about my pumping station, and how it is run. I have got used to this method of pumping, and am satisfied with it; as to its comparison with steam, I think it far ahead at small works.

There are risks attached to it, and more than that, there is the anxiety to the one who is responsible for the town's water supply; for no matter where one is, if that engine has been left running, one sort of feels it, and can imagine all sorts of things happening that are the source of continual anxiety. And this phase of the matter that cannot be measured in dollars and cents is part of the price you pay for running a plant of this kind.

Naturally, you get used to its running, and it does not weigh so heavily on you as time goes on, and you become accustomed to it. But when I first ran this plant the thing hung over me like some impending disaster; and I would find myself, when getting anywhere near the pumping station, listening to hear the exhaust of the engine, and unconsciously urging my horse to a faster trot to get there before something happened.

If, however, you are willing to put yourself into it and give it your watchful care, you will find it does your work for you in a way that will almost win your love, — certainly, your admiration.

As to my estimate of running this kind of a plant, and what it will do, I have tried to give you a fair idea of what it costs and what it will do, under present conditions. There are, of course, repair expenses that no one can estimate beforehand.

We had an engine once that put us to no end of bother and expense, and I have not included in what I have said any account of the expense either of repairs or labor on that engine, because it seemed to me that there must have been something radically wrong with it from the first, and it could not with fairness be compared with the ordinary machine of this kind; and so my estimate of running cost has been confined to the two engines now in use at our pumping station.

DISCUSSION.

Mr. Frank L. Fuller.* I should like to ask Mr. Agnew whether he has figured out what it costs him per hour per horsepower to do this pumping?

Mr. Agnew. You can very easily figure that from the foot pounds. I gave about twelve million foot pounds.

The President. Mr. Tower, of Cohasset, who is a neighbor of Mr. Agnew, ought to be able, as Mr. Agnew says, "to tell us some tales out of school."

Mr. D. N. Tower.† Mr. President, I do not think I can add anything to the very excellent paper we have just listened to. Mr. Agnew seems to have covered the whole ground.

Mr. William H. Thomas.‡ I think, Mr. President, that Mr. Tower can give us a little more information in regard to attendance. I do not think he requires as much attendance for his machine as Mr. Agnew reports he does on his, and I wish he would tell us how he operates.

Mr. Tower. I have two engines, and they differ from Mr. Agnew's in this respect, that they are located quite a distance apart, more than a mile, and I run one during the night and one during the daytime. My man who looks after them lives about midway between the two engines. He starts off in the morning, I don't know at what time, probably about half past six, and he passes the reservoir on the way, takes note of the condition of affairs there, and then walks along and stops the engine which has been running all night. He gets down to the other engine at about seven o'clock and starts that up, and then goes about his day's work. About five o'clock in the afternoon he goes to the engine which has remained idle during the day and starts that up and then proceeds to the one which has been running during the day and stops it. That is the way he has been doing all summer.

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* Civil Engineer, Boston, Mass.

† Superintendent of Water Works, Cohasset, Mass.

‡ Superintendent of Water Works, Hingham, Mass.

The cost of attendance is probably about the same as in Mr. Agnew's case, only it covers the two engines. Each engine pumps about nine thousand gallons an hour. I don't know anything more that I can say.

MR. AGNEW. I would like to say that I did give you a good generous allowance for attendance, and did it purposely. The tendency in a paper of this kind is to minimize the " outs "; and when we make a report about our engine's doings, we somehow like to give it a good name and make a good showing. But really, if anything, I have gone the other way in this case and have allowed more time than it actually takes. I, myself, have been to the pumping station, started the engine and left the place inside of twenty-five minutes. It wouldn't pay, probably, to try to do this all the time, and further, I would not want a man of mine to do it at all, for I would be afraid that in his hurry he would overlook something and then it would take more time and cause more trouble to fix up the damage than it would have taken at the start. However, an hour is ample time to start, and in the evening if the engine is running smoothly and you want it to run all night it will take about fifteen minutes to oil up.

Week before last I started up one of my engines Saturday at 3 P.M., that was September 1, and it ran continuously till midnight, Sunday, September 9, a run of two hundred and one hours. Now the only time spent on the engine during this run was to oil up twice a day and this took about fifteen minutes each time, or a half hour per day for attendance. We finally allowed the engine to run down itself by putting oil enough in the small tank to run it to about midnight. So you see that when I allowed that three hours per day for attendance I made it pretty large, and I did it because I had rather be on the safe side than to lead some man into the belief that the engine could run with practically no attendance at all, for it really *does* take some time to look after it.

MR. FREEMAN C. COFFIN.* I believe I have about recovered from my fright now and can say a few words on this subject. I was, perhaps, responsible for the installation of the first engine of this class which was used for pumping water for a public water supply in this section of the country, the one Mr. Tower has at

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* Civil Engineer, Boston, Mass.

Cohasset, and I have advocated the use of this type of power for pumping engines in small supplies for some eight or ten years, and have put in perhaps twenty such plants. I was a little afraid, or, to tell the truth, I was a good deal afraid, when Mr. Agnew began his paper, that he was going to demolish all my theories and show how poor a plant this was for pumping water. I feel much gratified at what he has said, in spite of his troubles, which I believe are incident to all plants, and perhaps show up a little more in an explosion engine plant than in any other, on account of the lack of attendance which is given it.

Of course I do not know so much about them as the men who are running them and looking after them all the time. I have tried to ascertain all I could about them, and while I am not entirely familiar with details, I believe that in most cases the engines have run right along without very much attendance. Of course, in a good many of the plants I have put in, considerable attendance has been given them, but it has not been like the attendance which has to be given a steam engine, by any means; and the expense of these plants, as compared with the expense of a steam engine, is very small, when you are pumping less than two hundred thousand gallons of water a day, or even more, at the price of fuel oil as Mr. Agnew states it. I have always been accustomed, until within a few years, to compute the cost of oil or gasolene at twelve or thirteen cents a gallon, perhaps more, which, of course, makes the fuel cost of one of these plants high, and quite excessive, perhaps, if it were not offset by the saving in attendance.

A kerosene-oil engine, I think, presents a little more difficulty than a gasolene engine. A gas plant, on the other hand, rather less. I put in two gas engines in Charlottetown, Prince Edward Island, where gas could be obtained at a reasonable price and gasolene was very high, and there has been no trouble whatever with those engines. They are used for pumping sewage. At Winchester, Mass., I have put in one gasolene plant and one kerosene plant, and they have never given any serious trouble. One of them was designed to stop itself, in the way Mr. Agnew has explained. There is a measuring tank with a glass tube to gage the quantity of oil. That is in addition to the outside tank which holds the main body of oil. From the outside tank to this one the oil is pumped by a small hand pump, and by examining his gage the engineer can tell at any time how much oil he has, the idea being to pump enough oil in for the run and let the engine stop itself. In that engine the cooling water for the cylinders is provided by a circulating tank, so that there is no waste of water when the engine is stopped. I don't know how the cylinders of Mr. Agnew's engine are cooled, whether by running water or a circulating tank.

MR. AGNEW. We have a little auxiliary pump bolted to the side of the engine bed and operated by an eccentric on one of the shafts of the engine to pump the water for cooling purposes. As I said at the outset we get our water from driven wells and pump against a considerable vacuum, twenty-five inches. This is quite a pull on the pump and in order to save this good water and also to save such a lift we use water for cooling the engine from a brook that flows back of the pumping station. This water is not suitable for domestic purposes, and there is practically no lift, for the brook is not much lower than the pump.

MR. COFFIN. I was very much interested in what Mr. Agnew said about the efficiency of the pump being a little over 12 000 000 foot pounds to a gallon of oil. That runs up very well indeed, especially when it is considered that that is the ordinary run of the pump and not a special test. On a test of one pump that I put in at Madison, Me., we got 14 000 000, and that I considered very high, but the conditions were quite good, and the conditions make a great deal of difference in the efficiency of a plant of this kind, that is, the head and the amount of water pumped. The conditions at Scituate are apparently very good.

I think this subject of the internal explosion engine is a very important one at this time, because it seems to me that everything points in the direction of the use of these engines for large plants for pumping. The gas producer plant, if it proves to be able to do what it promises to do, is in my opinion going to almost revolutionize the method of pumping water. Mr. Thomas has such a plant which has not been running very long, but I understand it has been very successful so far, and I hope he will tell us something about it. If power can be produced at the rate of one horse-power per 1¼ or 1½ pounds of coal per hour, as I understand the companies who furnish gas-producer plants are ready to guarantee, of course it is very easy for us to see that there is an immense gain over the steam plant, for our best steam plants, our very high-priced high-duty plants in large mills, will not do that. I do not know of any of them that can be depended on to get down to a pound and a quarter. I hope Mr. Thomas will tell us something about the plant which he actually has in use.

MR. THOMAS. I do not think I can say much about it at present, as it is new to us. We pump our water twice, once by a gas-producer plant and once by a steam plant. In our gas-producer plant we burn about 1 000 pounds of coal a day, and pumping the same quantity of water with the steam plant we use a little over 4 000 pounds, so you see there is a little saving in fuel. But the conditions at the two stations are not identical. For instance, at our gas-producer plant, we are pumping against only 16 pounds, and with our steam plant we are pumping against about 80 pounds pressure, so the conditions are not fair for comparison. I think, perhaps, at one of our later meetings I may be able to give a little information in regard to this plant.

MR. E. H. FOSTER* (*by letter*). One of the most interesting cases of "pumping without attendance" is to be found at the water works in Peoria, Ill., where there has been in use since 1895 a system of pumping water through auxiliary wells, which was designed and constructed, and later made the subject of letters patent, by Mr. Dabney H. Maury.

This system comes about as close to being "pumping without attendance" as possible, and was a case of invention born of necessity.

The water supply at Peoria is taken from a large open well, 53 feet deep and 34 feet in diameter, sunk in water-bearing gravel near the pumping station. This well gave enough water for the immediate needs of the city, but as the consumption increased an additional supply was soon found to be necessary. Careful surveys were made and test wells sunk with the result that it was decided to build a number of new wells about 800 feet apart and pump over ground to the main well.

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* Mechanical Engineer, New York, N. Y.

These wells were about 11 feet in diameter and were large enough to contain a set consisting of a pair of compound centrifugal pumps driven by direct connection to Pelton water wheels, the shafts being vertical. The motors derive their power from a water main connected with the town system near the pumping station, and the waste water from the motors is returned together with the water pumped from the smaller wells through a gravity line to the main well. Weirs for measuring the pumping capacity were fitted at the various wells.

The system has not only been in successful operation since first installed, but has been extended from time to time as the consumption increases.

No attendance whatever is required at the outlying pumping stations, as the motors are stopped and started by opening and closing the valve in the main pumping station.

It is somewhat surprising that this system has not become of more general use. It might at first seem somewhat complicated to take water from the mains to operate the auxiliary pumps, but in reality this will be found to be most efficient, providing the main pumping capacity is large enough to furnish the extra water.

The combined efficiency of the pump and motor is approximately 50 per cent.; thus if the water has been pumped into the main supply at a duty of say 120 000 000 foot pounds, the net duty of the auxiliary plant will be about 60 000 000 foot pounds, which is high for a small unit, particularly when it is considered that no attendance is required.

The system has been found to work very well, and when brought into more prominence will undoubtedly be used where additional supply, filtration or any special service requires a low-pressure pumping plant.

MR. A. A. REIMER.* Mr. Foster's communication suggests a point I was going to raise, that of pumping by a centrifugal pump with electric motor drive. In East Orange, N. J., we have installed within the past three years a new plant for furnishing about 27 000 or 28 000 people with water from artesian wells, having in use as the main pumps two four-million-gallon cross-compound high-duty Snow steam pumps. There are two groups of wells with twenty flowing wells in each group. One group, lying about a mile from the main pumping station, is lower than the main station, and the artesian head is not sufficient to lift the water over the low summit which lies between the pumping station and the second group of wells. In order to pump this second group of wells we are installing at the present time, at a substation near these wells, a centrifugal pump and electric motor guaranteed for five million gallons capacity.

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* Superintendent of Water Works, East Orange, N. J.

The question has arisen in my mind as to the safety of operating that substation without attendance. You realize that if anything should happen to that large electrical unit, there is going to be trouble. We are protecting the motor with all the best safety devices, but in case of accident, with a mile intervening between the main station and substation, we might be in serious trouble; so I was hoping I might hear some experiences to-day on the part of others who may have similar plants. There is only one that has come within my own observation, and that is at Newton, Mass., which I had the pleasure of visiting some time ago. There the substation is about 1 500 feet from the main station, and it is run with only occasional attendance, the pump being started by means of switches in the main station. That is what we are intending to do, and I wanted to gain a little further light from the experience of others at this meeting, if possible. We are getting ready now to start, and we are going to watch with a great deal of anxiety, I suspect, for a while to find out if things are going to run smoothly. I am not hunting trouble, but I want to keep away from it if I can.

MR. FULLER. I might say that at Uxbridge, Mass., they have installed a triplex pump with a capacity of about three hundred gallons per minute, which will be run by a General Electric motor, operated by current furnished from the local electric light station. The plant has not been in operation as yet, but we are hoping that it will be possible to run it without having to spend a great deal on the item of attendance. So far as it has been tried it has run very well indeed, and there has been apparently no need of any attention except keeping the oil cups filled and a man going once a day to see if everything is all right. The pump can be started and stopped from the power station, and the item of attendance apparently will be quite small.

MR. COFFIN. I wish I could give a little more definite information on this subject than I am able to at this time. I put in a plant at Madison, in connection with the engine I spoke of a little while ago, where we wished to take water from a point up stream from the old pumping station, where the water was pumped by power, and to use the power at that station. A generator was put in and the power transmitted to the new pumping station, perhaps three quarters of a mile up the river, above where the sewage of the town came in. There is a triplex pump of about half a million gallons capacity, as I remember, and I have heard no complaint at all about it, so I suppose it has been running satisfactorily and continuously. It was supposed to be started in the morning and left to run through the day, or perhaps longer than that if the consumption of water required it. It is only an assumption that it has been successful, from the fact that it has been doing the work and there has been no complaint and no criticism.

MR. FULLER. I think, Mr. President, that this comparatively new form of triplex pump is going to be largely used in small plants, because, as has been stated here, the item of attendance is small, the cost of the building is small, no expensive chimney is required and the building can be quite small, and where the electric current can be had at a low rate, or, as in the cases which have been presented to us, where the cost of fuel oil or gas is small, it certainly is going to simplify the pumping question. A good many towns are hardly able to put up an expensive pumping plant and employ a licensed engineer, and there are other items which come in to swell the cost of that kind of plant. These pumps are simple, easily kept in repair; an ordinary man by spending part of his time will keep everything in order, and it seems to me it will be a great help to the average small town if such pumps can be used.

PRESIDENT SEDGWICK. In regard to the criticisms which the public may make in any case of failure of the water supply, it seems to me that where there are plants of this kind the superintendent or the water board, or whoever the authority may be ought at the outset to take the public into his or their confidence and say, " Now we are trying to get along cheaply. Once in a while there may be trouble, and you have got to bear your part of any such hardship as well as the rest of us." And an intelligent community, if educated and taken into confidence in that way, will, I am sure, always respond. That will relieve the engineer or superintendent of some of that care which Mr. Agnew has touched upon, and which is no slight matter. It seems to me that any man who leaves a pump going while he is away must always have it, consciously or unconsciously, on his mind, and that is a pretty serious thing physiologically. In the case of a nervous man it might even mean a breakdown. Therefore in a case of this kind it seems to me that we ought to do what we do so much in America and what they are now doing everywhere all over the world, namely, take the public into our confidence and expect them to coöperate with us, rather than to " keep dark " and tell them, " Oh, it will be all right; don't you worry," and so on; because otherwise when the time of worry comes the man in charge has to bear it all.

In this connection I was reminded of the old rhyme, which some of you will probably remember, about care and its effect on us:

> " Care to our coffin adds a nail, no doubt,
> And every laugh so merry draws one out."

When Mr. Coffin began speaking I was reminded of these lines, for he suggested that he was frightened " nearly to death," and they came to me in this way:

> Care to *our* Coffin adds a nail, no doubt,
> While every 'pump-without-attendance' draws one out.

EXPERIENCE WITH NEW ENGLAND WATER WORKS ASSOCIATION STANDARD SPECIFICATIONS FOR CAST-IRON PIPE AND SPECIAL CASTINGS.

TOPICAL DISCUSSION.

[September 12, 1906.]

MR. CHARLES W. SHERMAN. I don't know that I have much to say in the way of personal experience with the specifications, but it may be interesting to the members to know how extensively the sale of these specifications has gone forward. They were adopted at the annual convention four years ago. Immediately thereafter the association commenced to print them in pamphlet form for use by members and others interested. We have had printed at different times 4 000 copies, all of which have been sold at retail by the Secretary, with the exception, perhaps, of 500 copies still in stock. In addition to that we have supplied two parties with 1 000 copies each, one thousand to the National Fire Protection Association, which wished to furnish a copy to each of its members, and the second thousand to the new American Cast Iron Pipe Company, of Birmingham, Ala., which has adopted our specifications as the standard on which to cast all its pipe, and has had them printed with its special cover to circulate as its catalogue. My understanding is that any one who sends to that company for a catalogue will receive a copy of these specifications, simply bound in a special cover bearing the name of the company. In addition to that I have been informed by correspondence that the Lynchburg Pipe and Foundry Company, of Lynchburg, Va., which, I believe, is a comparatively small foundry, confining itself to pipes 12 inches in diameter and smaller, is working on the basis of our specifications. On the whole, it is a very encouraging experience, it seems to me, for so short a time.

When it comes to the matter of buying pipe under the specifications from the old established foundries, the matter is not quite so simple. I was speaking on the subject with Mr. Brackett a few days ago, and he said it seemed to him conditions this year were such that they compared very nearly with conditions during the coal strike a couple of years ago. At that time we had to buy almost anything which was black under the name of coal, and now we have to buy almost anything which is iron as pipe, no matter whether it is made under our specifications or no specifications. I found very much the same thing, not only this year but last year, in getting small quantities of pipe for one of our western water companies. Whether they were bought from the United States Cast Iron Company or one or two other foundries which pretty nearly dominate the western field, we had to take their special patterns. They would, however, give us the slight comfort of agreeing to comply with our specifications so far as inspection is concerned, but that was about all.

Mr. A. A. Reimer. Speaking of trouble with the foundries, I can tell a little experience that we have had in East Orange. After the annual meeting of this association last year, I decided to adopt for East Orange, N. J., the New England Water Works specifications, and since then all our orders have been placed on that basis. The foundries have given us no trouble, with the exception of the United States Cast-Iron Pipe and Foundry Company. This company would always send in a bid for pipe, but would inclose specifications which looked about as much like the New England Water Works specifications as a cow does like a horse, and in consequence their bids have uniformly been rejected; we would not listen to them at all, and this summer I decided to stop asking them to bid. Why they have taken this position is not for me to state. The other foundries with which we have been doing business have agreed to the specifications without any question, and orders have been delivered with reasonable promptness.

REPORT OF THE COMMITTEE ON "UNIFORMITY IN THE DIRECTION OF OPENING HYDRANTS AND VALVES AND IN THE SIZE AND SHAPE OF HYDRANT AND VALVE NUT."

[Presented September 13, 1906.]

Your committee, which was appointed at the New York meeting of the association, in September, 1905, begs to submit the following report:

The lack of uniform standards in matters relating to water supply and fire protection has been long felt by water and fire departments, by manufacturers of appliances connected with these departments, and by water-works engineers, and has caused serious losses to owners and underwriters.

A notable advance has been made in this direction by the adoption by this association of the recommendation of a committee, which reported at the New York meeting in September, 1905, on "Uniformity of Hose and Hydrant Threads."

The matters referred to your present committee, while not of equal importance, are closely related and worthy of careful consideration. The greatest efficiency in the use of apparatus of any kind is dependent upon its simplicity, and uniformity tends to simplicity.

PRESENT CONDITIONS AS TO UNIFORMITY IN WATER WORKS AND FIRE DEPARTMENT APPLIANCES.

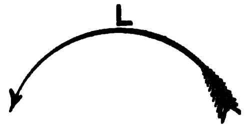
The present lack of uniformity is more largely accidental than intentional. In the early days of water-works construction, each city and town was practically a law unto itself in such matters, paying but little regard to the methods employed in other municipalities. The manufacturers supplied the needed appliances in a form to suit their customers, and while better designs and possibly better materials are now employed, the important element of uniformity has not yet been entirely secured. It is not surprising that there should have been this lack of uniformity in many particulars, when the great number of manufacturers and the still greater number of users, with their different ideas of what is best, are taken into account.

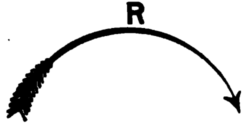
This report has to do with three matters of great importance, where uniformity does not and never has existed. They stand next in importance to a Standard Uniform Hose Thread.

There is no accepted standard for either the operating nut on valves connected with street mains or for the nut on fire hydrants, and different patterns of each are in use. This is especially to be regretted in the latter instance, because the hydrant wrenches of one fire department will not necessarily fit the hydrants of another. Therefore assistance is often delayed when promptness is of the utmost importance.

Uniformity in each of these two cases ought not to be difficult of attainment, and it is surprising that it does not already exist. No time should be lost in recommending a standard for each.

No uniformity exists as to the direction in which either a hydrant or a street valve turns to open; in some cases they turn to the left, and in others to the right, to open.





There appears to be much greater, if not practically entire, uniformity in the direction of opening of nearly all steam valves, the larger number of small water-works fittings, such as faucets or bibbs, and in almost all water valves found in pumping stations, or connected with pumping engines, which generally open to the left. These far outnumber the valves and hydrants found in the streets, a portion of which, it is to be remembered, now open to the left.

By means of correspondence with manufacturers, a statement has been obtained of the percentage of hydrants and street valves furnished by them during the last few years which open to the left, and this information is shown in the following table:

	Per Cent. Opening to the Left.	
	Hydrants.	Street Valves.
Ludlow Valve Manufacturing Company (sales for past five years, 5 000 to 6 000 hydrants yearly)	40	40
Coffin Valve Company (as furnished to about 200 cities and towns)	45	45
Eddy Valve Company (since March 1, 1901) . .	84	60
Rensselaer Manufacturing Company	80	60
Chapman Valve Manufacturing Company . . .	50	25
R. D. Wood & Co.	87½	40
The Fairbanks Company (within the last three years)	11	about 80

The Ludlow Valve Manufacturing Company state that " during the last twelve or eighteen months (letter dated April 4, 1906), the number of hub valves and hydrants which open to the left has greatly increased."

It is safe to assume that no change will ever be made in the direction of opening steam valves and the small fittings just alluded to, which open to the left. They are too numerous and their use so well established that it would be practically impossible to make any change in the direction of opening, even if it should seem desirable.

There can be no doubt that the majority of the hydrants now in use, in New England at least, open to the right. Boston, as the pioneer, inaugurated the practice of opening all hydrants and street valves in this direction, and many of the other cities and towns have adopted the same method. Of late (according to a statement of the Ludlow Valve Manufacturing Company), there has been an increase in the number of hydrants and valves opening to the left.

It thus appears that a majority of all valves, both steam and water, and all small water-works fittings, as well as a portion of the fire hydrants now in use, open to the left.

There is probably no difference in the facility with which hydrants and valves can be opened, whether it be to the right or left.

RECOMMENDATIONS.

After careful consideration of present conditions and an earnest effort to judge wisely as to the future, your committee suggests for the consideration of the association the following recommendations:

1. In new systems all hydrants and valves shall turn to the left to open.

2. All additions and repairs to existing systems of hydrants and valves shall be such that there shall be continued uniformity in the direction of opening, whether it be to the left or to the right. If no uniformity already exists, all new apparatus shall turn to the left to open.

(*a*) A city or town having an established system of water works should continue to install hydrants and valves having the same operating nuts and opening in the same direction as those already in use, unless it has been decided to at once change all old hydrants and valves to the new standard. This principle is imperative and no departure should be made from it. It is unfortunate that entire uniformity was not earlier advocated and adopted. The very rapid increase in water-works appurtenances, great numbers being turned out daily, increases the importance of uniformity.

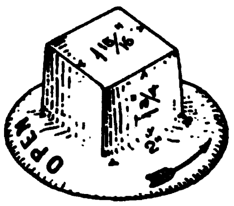
3. All fire hydrants shall have a pentagonal (five-sided) operating nut finished without taper to one and one-half (1½) inches from " point to flat." The nut socket in the wrench shall be made without taper so as to be reversible.

(*a*) This size and shape of nut is in quite general use and has been recommended by the National Fire Protection Association.

4. An arrow at least six (6) inches long, showing the direction of opening and the words *to open* in distinct letters at least three-quarters (¾) inch high, shall be cast with one-eighth (⅛) inch relief, upon the top of all fire hydrants.

5. All valves connected with street mains shall have an operating nut one and fifteen-sixteenths (1$\frac{15}{16}$) inches square at the top, two (2) inches square at the base, and one and three-fourths (1¾) inches high.

6. The operating nut on all valves shall be made with a flanged base upon which shall be cast an arrow, at least two (2) inches long, showing the direction of opening and the word *open* in distinct letters at least one-half (½) inch high, as shown in the sketch.



The standard direction for opening hydrants and street valves is a perplexing question and there are sure to be differences of opinion. The standards recommended are for new systems and for such others as choose to change. It will be many years before entire uniformity can be secured, and then only by the earnest coöperation of those who believe uniformity to be worth striving for.

Frank L. Fuller,
Frank C. Kimball,
Edward V. French,
Committee.

DISCUSSION.

Mr. Frank L. Fuller. *Mr. President and Gentlemen:* I regret that I am the only member of this committee present. Mr. Kimball, as you know, has gone to the state of Washington. I had a letter from him a few days ago, in which he said that of course it would be impossible for him to be present at this convention; that he regretted losing so many of our meetings, and he further said that he shouldn't live in Washington all his life unless his life was very short. Mr. French had been away on a vacation, and he regretted very much that he could not be present, and he wished to be remembered to all the members, and desired me to say in connection with this matter of uniformity that he was present at the fire at Fort Fairfield, Me., recently, and that the effect of the lack of uniformity there was lamentable. A steamer came from an adjoining town and was perfectly useless, could do nothing, because it could not connect with the hydrants in the town. That trouble was sought to be remedied by the committee which reported last year in New York in presenting a recommendation for uniform thread for hose and hydrants, which was adopted.

Of course we realize the difficulty of the situation, but we hope the association will adopt these recommendations and that all the members will use their influence to have this matter of uniformity brought about. We realize that probably there will be difference of opinion, and that all the members will not agree with this report, and we will be glad to hear from those who have different ideas. For the sake of bringing the matter before the meeting, I will move the adoption of this report and the discharge of the committee.

MR. M. F. COLLINS.* Before the motion to accept the report is adopted, I should like to ask Mr. Fuller if he gave the size of nuts on the independent valve stems any consideration, and whether it wouldn't be advisable to have them the same size as on the main valve stem, so you wouldn't have to have, as we do at the present time, a small part attached to the wrench for the small independent hose connection.

MR. FULLER. I am very glad Mr. Collins has brought this matter up. As I understand him, he refers to the nuts which operate the small independent gate valves on a 3-way or a 4-way hydrant.

MR. COLLINS. Yes.

MR. FULLER. It seems to me, Mr. President, that it would be very much too large. Those nuts, as I remember them, are not more than one-half or three-quarters inch square, — half an inch, Mr. Bancroft says. Now I think the committee would be very glad to incorporate a recommendation that these small auxiliary valves be operated by a half-inch nut, if that is the usual size. Perhaps the committee were a little negligent in not looking into this matter, and I am very glad Mr. Collins has brought it forward, for I can see that that is also a matter in which uniformity should exist. By inquiry I think we could find what the common size is, and perhaps it would be wise to adopt that.

MR. COLLINS. I think, Mr. President, that Mr. Fuller is perfectly right about the usual size of this small nut, but we are putting in an independent high-service system at Lawrence, having a pressure of from 125 up to as high as 134 pounds, and in having the hydrants made, we had the heads made the same size on the small independent 2½-inch hose connections that they were on the main spindle, so a man wouldn't have to turn the wrench over at all. I thought I would bring the matter to Mr. Fuller's attention to see what he thought of it.

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* Superintendent of Water Works, Lawrence, Mass.

Mr. Freeman C. Coffin.* I should like to ask Mr. Fuller if he has heard any complaint that the stems, as they are made now, are too weak? I have heard some complaint of that kind, and the suggestion that they might be made larger or stronger than in the past.

Mr. Fuller. Yes, I think Mr. Coffin is right, that these stems are too small for the wrench which is likely to be used, and apt to twist off. My own idea is that it is much better to screw an independent valve (such as are carried in the hose wagons) on each outlet nozzle of the hydrant, and connect the hose with this valve, rather than have these independent gates which are inside the casing of the hydrant, and which are forever getting out of order. In the excitement of a fire it is very apt to be the experience, I think, that these small stems, being so small, are twisted off and broken, and trouble ensues; when you want to shut them, you can't shut them. But if you have an independent valve, operated by a hand wheel, on each hydrant opening, you avoid this danger. I notice that some of the manufacturers of hydrants place an independent valve on each nozzle of the hydrant. Possibly this matter ought to have received more attention from the committee.

Mr. Alexander Orr. In connection with the 4-way and 3-way hydrant, the hydrants which have been shipped to our department lately do not have this auxiliary valve inside the hydrant barrel, but on the outside, being an entirely auxiliary valve with a wheel at the top. That type of hydrant, I understand, is the one which is recommended by the National Fire Underwriters Association, and, in fact, it is the hydrant which was specified by them in some of our work.

Mr. George A. Stacy.† While the spindle for the auxiliary valve or independent nozzle, I think, is amply large enough to open or close the valves, the trouble is with the implement we are obliged to employ in opening and closing these small valves. The wrench is practically the same length and gives the same leverage as that which opens the main gate of the hydrant. You know that all the men who run in the fire departments are not mechanics, and they get the same leverage on the small stem that they do on the main gate. I have had two broken in that way, not because the spindle wasn't strong enough to open and close the valve, but because the man with the leverage he was using was too strong for the spindle. These spindles would do the work if the leverage was reduced to a point where it would be impossible for a man to overcome the factor of safety, but they can't stand the strain where a man with a long wrench uses the same strength to open or close a 2- or a 2½-inch valve as he does to open or close a 6- or 8-inch gate. I think that the valve which is put on the outside of the hydrant, with a wheel giving the leverage adapted for that size of valve, is the proper thing (when placed in a mill yard), as called for by the underwriter specifications and recommended by them for use in their mill equipments. If placed on the hydrants in our public streets, I think there would be danger of their becoming damaged and inoperative by the ever-present small boy and the malicious that are in every community. I think you agree with me that no hydrant maker makes a valve stem which is not amply able to open or close the valve without breaking, and that the trouble is with the wrench.

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* Civil Engineer, Boston, Mass.

† Superintendent of Water Works, Marlboro, Mass.

Mr. Collins. I think this discussion has brought up something which is going to be of some benefit to the association, and while I don't want to impose any more work on Mr. Fuller than is necessary, I think it would be wise to accept, but not adopt, the report to-day, and then to give him a little more time in order to look the matter up and talk with the hydrant men, and in the winter he may have something to suggest to us on the opening of the independent 2½-inch hose connections.

Mr. Stacy. I am not of Brother Collins' mind in regard to not putting any more work on to Mr. Fuller, for I think he has had too easy a time. I was on the committee on uniformity of hose and hydrant threads, and we had quite a job on our hands, and I don't want Brother Fuller to get out of it any easier than we did. He has made what I call an excellent common-, horse-sense report on this matter, as far as he has gone, but I think he can spread out a little more and take in the other details with a great deal of satisfaction to himself and benefit to the association, and I don't think we ought to adopt this report until he covers the ground more fully.

Mr. Fuller. I am sorry Mr. Stacy thinks I have had so easy a time. As I told you, Mr. Kimball is in Washington, and it takes about two weeks to get a letter to him and receive an answer, even if he writes immediately. Mr. Kimball has been very good and said he would help us all he could. Mr. French, as you all know, is an extremely busy man, and acquiesced in my offer to draft a report. So I wrote out the report and sent copies to the other members of the committee. Mr. French was away on his vacation, but he had one of his men come down to my office, a very bright young man, who had had considerable experience in getting out similar papers, and together we went through it, and then I re-submitted it to Mr. French and he thought it was substantially right. Mr. Kimball also sent his approval. I think the points raised by Mr. Stacy and by Mr. Collins are good ones, and the committee will be glad to give proper attention to this matter of independent valves, look into it, and add to this report something in this connection and present it at some meeting next winter. I think the committee would be glad to get the thing into shape and have the matter settled.

Mr. A. E. Martin.* If the committee wants any more information on this subject, I would suggest that they write to Mr. A. W. F. Brown, water registrar at Fitchburg. I had occasion to visit him a little while ago in regard to some high-service fire protection; he is not only water registrar, but he takes a great interest in the fire department, — runs to about every fire they have and helps out, — and I don't think he would recommend any auxiliary valves at all. In fact, he talked very much against them. He said they were almost always found to be shut when they ought to be open, or open when they ought to be shut, and very often a spindle was broken or otherwise damaged, particularly if the highway department were allowed to use the hydrants. It occurred to me that perhaps the committee might get some useful information from him.

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* Superintendent of Water Works, Springfield, Mass.

Mr. Stacy. I would suggest, Mr. President, that we accept this report of the committee as a report of progress, and request the committee to make a further report at some early meeting next winter.

Mr. Fuller. I will withdraw my motion that the report be adopted.

The President. Then, if there is no objection, the report will be accepted as a report of progress, and the committee requested to continue its work and report finally at some meeting next winter.

Mr. Charles W. Sherman. Before the matter is closed there is one other point in connection with it which, it seems to me, the committee might consider with profit in its future deliberations, and which is of a good deal of interest in connection with one of the works, at least, with which I am connected. In one small water system which we are operating there are valves opening in both directions, and this is not quite so uncommon a thing as might be supposed. I have instructed the superintendent of the works to go over the system and mark, with the most durable white paint he could get, an arrow on the under side of the valve-box cover, showing in what direction the particular valve opens. Most makers of valves also make the standard cast-iron valve boxes which are in general use, and why the covers of those boxes should not be made with large arrows on them, — good, large, prominent arrows, which would show even if the cover got rusty, — I don't see. Of course you would have to buy a supply of covers with right-hand and left-hand arrows, if you had both kinds of valves on the works, but that would be a small matter.

Mr. Coffin. There is one suggestion I should like to make, and I make it modestly, for I haven't thought much about it. It certainly is very desirable that every water works should have uniformity in regard to opening of valves, and all valves certainly should open in the same direction, and it is very unfortunate that matters are in the condition that they are at present. It seems to me it might not be a very expensive matter for towns where there are valves opening in both directions, which desired to adopt a standard,— probably the left-hand standard,— to put on a gear simply to reverse the movement of the valve. I think a device could be made very cheaply and applied to the flange of the bonnet or hood of the valve without removing the valve or even shutting off the water. One of the gears could be put on in place of the present nut on the end of the stem. I think an apparatus of that kind might be designed at a cost of perhaps less than a 6-inch gate, perhaps not less than a 4-inch gate, and it would obviate any taking up of gates and cutting up pipe lines, etc. I would make the suggestion that the committee consider if anything can be done in that direction.

Mr. J. D. Hardy.* Holyoke is one of the places which are unfortunate in having their valves open one way and their hydrants the other way. When they started in to build the works I suppose they didn't think much about that, and we have so many valves and gates now that it would be almost impossible to change them. They are making in Holyoke now what is called the Hercules independent gate to put on the outside of the hydrants. It has a nut, and one-half turn of that opens or closes the valve, and no wheel is required. I don't know what the effect of water hammer would be, but we are putting on quite a number of them now and we have had no trouble from those that are in use so far. They can be easily put on any hydrant, and if they work as they seem to be able to, I think they will be one of the best things that I have ever seen or known of for an independent gate on a hydrant. I don't think much of these things with a small nut on top. I know I put one in one day, and the very next day the firemen went to open it and they broke the nut, disabling the hydrant for that fire. But the Hercules can be readily taken off should it break, though I see no reason why a fireman, even if he loses his head, should break it.

Mr. J. C. Gilbert.† The works in our town were put in in 1883 and 1884, and when we called for bids for hydrants, the parties who came forward told us that most hydrants sold at that time opened to the right. The committee — I had the honor of being one of the committee — could hardly see why they should open to the right. We discussed the matter for a number of days, and finally decided that, let others have them as they would, we would have ours open to the left, and, therefore, we put in all our hydrants and valves and gates to open to the left, and I assure you we never have been sorry.

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* Superintendent of Water Works, Holyoke, Mass.

† Treasurer of Water Works, Whitman, Mass.

I recollect one little incident connected with it. We had a bad break on a pipe line where there were a number of large factories, and we worked all night to get the water on the line so the factories could have it early in the morning. We got through about five o'clock, and I told the foreman that when I went to breakfast I would open one of the gates on the main line before I had my breakfast, so that the factories could get water all right. I did so and then went home, and while I was eating my breakfast a man came up to the house post haste, and said that the factories were in great danger because they had started up steam and couldn't get any water. I immediately left my breakfast and started for the house of the foreman, who also had gone home, and I asked what it all meant. I said: " I opened the gate." He said: " I forgot what you told me, and I sent one of my men up there to open it." It was a mystery to us, and so I said: " Let us go up to the gate," and we went. This man had been working for the city of Brockton, where the gates open to the right; and we found that he had been there and turned down the gate immediately after I had opened it. We have but one gate in the town that opens to the right, and that is not in commission at present, as we have abandoned the well where it is located. It was set by a contractor, and we didn't know that it opened to the right until after it was put in.

Another little incident. Some two years ago we made a trade with the city of Brockton,—when they took water from Silver Lake, — for them to furnish us with water. Of course we had a large gate where we tapped their pipe. It was something like a mile from the center of the village. We got the job all completed, and at the last moment it was decided that we should have a sort of celebration when the water was let on, and I was selected as the man to open the gate. There were, I guess, a thousand people present, and after having pictures taken of all the dignitaries, I placed myself in position to open the gate. It was my good fortune to have one of the Brockton officials standing at my left. After making a short speech, I boldly attempted to open the gate, and it brought up solid. I was working at it with all my might when the Brockton man touched me on the shoulder and said, "It opens to the right." [Laughter.] It was too late, however, and the laugh was on me. The story got into the local papers and it has always been kept as a joke at my expense.

I never could see any reason myself for opening a gate to the right. What would you think of a manufacturer of screws who made them to turn down by turning to the left? It is just as natural if a man is going to turn a screw to turn it to the right as it is for him to breathe; it seems to be a sort of instinct, and it always seemed to me a very wrong thing to have a valve or a hydrant open to the right.

MR. EDMUND M. BLAKE.* I should like to say a word, Mr. President, along the line suggested by Mr. Sherman. The keeping of careful record plans of pipe lines, connections, hydrants, gates, etc., has advanced a great deal in the last few years, but there are still many cases, in cities where both right- and left-hand gates have been put in, where the record is not quite clear. This has been brought to my own notice in some recent tests which we have been carrying on in some of the large cities with the pitometer. In some cases fires have broken out, and in two particular cases the pressure was very much less than they had expected to get at a given point, and as the pitometer was in service at that time, it was used to investigate to see what the trouble was. In those two cases we found gates, which were supposed to be left-hand gates, which were really right-hand gates, and they were closed and had been that way for five or six years, unknown to any member of the department.

MR. FULLER. In regard to what Mr. Sherman suggests as to putting an arrow on the under side of the cover of the valve-box, would it not be well to put the arrow on the top of the cover as well as on the under side? The only objection I can see to putting it on the top of the cover is that it might possibly get worn off by the action of teams and wheels. If it is put on the under side, I can't see any objection to putting it also on the upper side. I don't suppose it would cost any more in making these covers to have two arrows instead of one, but it seems to me if there is to be only one, it would be better to have it on top, where a man taking off the cover would naturally see it.

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* Civil Engineer, Boston, Mass.

Mr. Sherman. I should certainly advocate casting the covers so as to have the arrow on both sides. My point was that in painting them on the covers, the paint wouldn't last any time at all on the upper surface, and so I told the superintendent to paint them on the under side, and then, of course, a man would have to turn the cover over to see in which direction to open the valve.

PROCEEDINGS.

JUNE MEETING.

"Field Day," June 13, 1906.

Excursion to Charlestown Navy Yard, and by steamer *Philadelphia*, down Boston Harbor and to Nantasket Point.

The following were in attendance:

MEMBERS.

S. A. Agnew, F. D. Berry, J. M. Birmingham, C. S. Burns, Jas. Burnie, C. E. Childs, P. M. Churchill, M. F. Collins, E. C. Crosby, Geo. E. Crowell, M. J. Doyle, E. R. Dyer, E. D. Eldridge, I. T. Farnham, J. N. Ferguson, E. W. Gaylord, J. C. Gilbert, A. S. Glover, A. A. Gould, J. A. Gould, J. W. Graham, F. S. Hollis, J. L. Howard, E. W. Kent, Willard Kent, G. A. King, J. W. Lynch, E. C. Levy, F. F. Longley, A. R. McCallum, Hugh McLean, F. E. Merrill, H. A. Miller, E. B. Phelps, E. M. Shedd, C. W. Sherman, J. T. Stevens, L. A. Taylor, H. L. Thomas, R. J. Thomas, W. H. Thomas, D. N. Tower, J. C. Whitney, W. P. Whittemore, Geo. E. Wilde, F. B. Wilkins, G. E. Winslow. — 47.

HONORARY MEMBERS.

W. T. Sedgwick. — 1.

ASSOCIATES.

Builders Iron Foundry, by A. B. Coulter; Chapman Valve Mfg. Co., by Edward F. Hughes; Fred C. Gifford; Hersey Mfg. Co., by Albert S. Glover; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by A. R. Taylor; National Meter Co., by J. G. Lufkin; Platt Iron Works Co., by F. H. Hayes; Rensselaer Mfg. Co., by C. L. Brown; Ross Valve Co., by Wm. Ross; Thomson Meter Co., by E. M. Shedd; Union Water Meter Co., by W. F. Hogan; R. D. Wood & Co., by W. F. Woodburn; Henry R. Worthington, by Samuel Harrison. — 14.

GUESTS.

D. L. Agnew, Scituate, Mass.; C. O. Bourne, Charlestown, Mass.; F. L. Cadou, Vincennes, Ind.; Miss S. Chambers, Miss M. Ebert, Buffalo, N. Y.; Miss Nellie DeGreefe, Amsterdam, N. Y.; A. F. Estabrook, Leicester, Mass.; Mrs. J. N. Ferguson, Boston, Mass.; C. O. Galvin, E. F. Garby, Worcester, Mass.; Mrs. John A. Gould, Newton, Mass.; Edward Hanlon, Cohasset, Mass.; W. C. Hopper, Paterson, N. J.; Mrs. J. L. Howard, Boston, Mass.; F. S. Inman, Akin, N. Y.; R. A. Jones, Waltham, Mass.; Mrs. E. W. Kent, Woonsocket, R. I.; A. A. Longley, Washington, D. C.; Miss K. S. McCarthy, Boston, Mass.; Mrs. H. A. Miller, Newton Highlands, Mass.; Miss Norwell, Chicago, Ill.; Mrs. Noyes, Gloversville, N. Y.; Mrs. E. B. Phelps, Boston, Mass.; Chas. Rollins, Watertown, Mass.; Chas. W. Ross, Mrs. Chas. W. Ross, Newton, Mass.; Mrs. G. M. Sargent, Kansas City, Mo.; Capt. Sears, Mrs. Sears, Lynn, Mass.; Mrs. E. M. Shedd, Somerville, Mass.; Miss Stizil, Chicago, Ill.; Mrs. R. J. Thomas, Lowell, Mass.; E. A. Winchester, Malden, Mass.; Mrs. G. E. Winslow, Waltham, Mass.; Mrs. B. M. Wood, Kansas City, Mo.; — 35.

[Names counted twice, — 2.]

Meeting was called to order on board the steamer by Vice-President Jos. M. Birmingham. Secretary Willard Kent read applications for membership from the following persons:

For Resident Member: Dr. Gardner T. Swarts, Providence, R. I.; Charles E. Childs, Somerville, Mass.; E. C. Crosby, Brattleboro, Vt.,

For Non-Resident Member: George M. Bacon, Salt Lake City, Utah; S. J. Rosamond, Fort Smith, Ark.; Robert J. Harding, Hudson, N. Y.; Charles L. Fox, Pittsburg, Pa.; A. W. Shaw, Brandon, Manitoba.

These applications were approved by the Executive Committee. It was voted that the Secretary cast a ballot for the applicants, and he having done so, they were declared duly elected to membership.

There being no further business, the meeting adjourned.

TWENTY-FIFTH ANNUAL CONVENTION.

FABYAN HOUSE, FABYANS, N. H.,
September 12, 13, 14, 1906.

The Twenty-Fifth Annual Convention of the New England Water Works Association was held at the Fabyan House, Fabyans, White Mountains, N. H., on Wednesday, Thursday, and Friday, September 12, 13, and 14, 1906.

The following members and guests were registered:

MEMBERS.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, F. A. Barbour, J. E. Beals, F. D. Berry, J. M. Birmingham, F. E. Bisbee, E. M. Blake, George Bowers, James Burnie, C. E. Chandler, J. C. Chase, F. C. Coffin, M. F. Collins, J. H. Cook, G. K. Crandall, C. E. Davis, J. J. Desmond, M. J. Doyle, Bartholomew

Dwyer, E. R. Dyer, C. H. Eglee, E. D. Eldredge, C. R. Felton, A. M. French. F. L. Fuller, J. C. Gilbert, W. J. Goldthwait, X. H. Goodnough, F. W. Gow, J. W. Graham, P. T. W. Hale, J. D. Hardy, H. R. Johnson, W. S. Johnson, Willard Kent, Patrick Kieran, G. A. King, Morris Knowles, F. H. Luce, Hugh McLean, H. V. Macksey, A. E. Martin, F. E. Merrill, H. A. Miller, J. T. Miller, F. L. Northrop, Alexander Orr, Washington Paulison, C. E. Peirce, T. A. Peirce, E. B. Phelps, A. A. Reimer, E. M. Shedd, C. W. Sherman, G. H. Snell, H. W. Spooner, J. F. Sprenkel, G. A. Stacy, G. T. Staples, R. J. Thomas, W. H. Thomas, J. L. Tighe, D. N. Tower, L. L. Tribus, C. K. Walker, E. L. Wallace, C. S. Warde, J. C. Whitney, G. E. Winslow, I. S. Wood, G. W. Wright, L. C. Wright. — 74.

HONORARY MEMBERS.

William T. Sedgwick, F. W. Shepperd.— 2.

ASSOCIATES.

Anderson Coupling Co., by Chas. E. Pratt; Ashton Valve Co., by C. W. Houghton; Builders Iron Foundry, by A. B. Coulters; Chadwick-Boston Lead Co., by C. N. Fairbairn; Coffin Valve Co., by H. L. Weston; The Fairbanks Co., by F. A. Leavitt and Chas. H. White; Garlock Packing Co., by J. E. Case; Hart Packing Co., by Horace A. Hart; Hersey Mfg. Co., by H. D. Winton and H. V. Macksey; International Steam Pump Co., by Sam'l Harrison; Jenkins Bros., by J. D. Stiles; Lead Lined Iron Pipe Co., by T. E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; H. Mueller Mfg. Co., by O. B. Mueller and Geo. A. Caldwell; National Meter Co., by C. H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Norwood Engineering Co., by H. W. Hosford; Pittsburg Meter Co., by F. C. Clifford; Rensselaer Mfg. Co., by C. L. Brown; Ross Valve Co., by William Ross; A. P. Smith Mfg. Co., by Fred Whitcomb; Thomson Meter Co., by Edw. M. Shedd; Union Water Meter Co., by F. L. Northrop, Edw. P. King and Chas. F. Merrill; Water Works Equipment Co., by W. H. Van Winkle; R. D. Wood & Co., by Wm. F. Woodburn.— 31.

GUESTS.

Mr. M. K. Murnair, Biddeford, Me.; Miss Dyer and Miss Robinson, Portland, Me.; Mrs. John C. Chase, Derry, N. H.; Mr. and Mrs. W. M. Gates, Nashua, N. H.; Mrs. E. L. Wallace, Franklin, N. H.; Mrs. T. J. Baker, Johnson, Vt.; Mr. Browley, conductor Mt. Washington Railway, Fabyans, N. H.; Mrs. G. H. Snell, Attleborough, Mass.; Mrs. Charles W. Sherman, Belmont, Mass.; Mrs. H. A. Hart, Mr. and Mrs. P. H. Gallaher, Mrs. Wm. S. Johnson, Miss Florence Kimball, Mrs. J. D. Stiles, Mrs. H. H. Kinsey, Mrs. H. V. Macksey, Mrs. Sam'l Harrison, Miss Joan M. Ham, Mr. L. C. Wason, Mr. T. P. Taylor, Boston, Mass.; Mrs. Charles R. Felton, Brockton, Mass.; Mrs. C. H. Eglee, Brookline, Mass.; Mr. and Mrs. James P. Bacon, Cambridge, Mass.; Mrs. D. N. Tower, Mary P. Tower and Bessie L. Tower, Cohasset, Mass.; Mrs. George T. Staples, Miss G. M. Staples, Dedham, Mass.; Mrs. Patrick Kieran,

PLATE I.

FABYAN HOUSE.

CONVENTION OF N. E. W. W. ASSOCIATION, SEPTEMBER, 1906.

Fall River, Mass.; Mrs. H. W. Hosford, Mrs. W. A. Stevenson, Florence, Mass.; Miss Elenor R. Goldthwait, Mrs. C. M. Gregory, Marblehead, Mass.; Mrs. H. W. Spooner, Gloucester, Mass.; George N. Cross, Haverhill, Mass.; Mrs. A. M. French, Holyoke, Mass.; Mrs. Wm. H. Thomas and Miss Helen A. Thomas, Hingham, Mass.; Mrs. J. J. Desmond, Lawrence, Mass.; Mrs. George Bowers, Miss Helen E. Bowers, Mrs. R. J. Thomas, Miss C. Walsh, Miss K. Walsh, M. E. Murkland, Lowell, Mass.; Eleanor A. Barden and H. B. Sylvester, Middleboro, Mass.; Buckingham Miller, Newton Highlands, Mass.; Mrs. S. A. Agnew and Miss Hattie F. Seaverns, North Scituate, Mass.; Mrs. E. D. Eldredge, Onset, Mass.; Miss S. C. Berry, A. W. Danforth, Alice A. Danforth, L. A. Danforth, Reading, Mass.; E. T. Harvell and Chas. A. Townsend, Rockland, Mass.; Mrs. E. M. Shedd, Miss Lillian E. Leavitt, Edwin Leavitt, Somerville, Mass.; Mrs. E. A. Martin, Springfield, Mass.; Miss Lucy C. King, Taunton, Mass.; Mrs. George E. Winslow, Waltham, Mass.; Agnes L. Coffin, John R. Coffin, W. Medford, Mass.; Mrs. F. L. Fuller, Clifford D. Winton, Mrs. H. D. Winton, Wellesley Hills, Mass.; J. E. Peirce, Emma F. Vaughan, East Greenwich, R. I.; Mrs. C. E. Peirce, East Providence, R. I.; Mrs. Irving S. Wood, Providence, R. I.; Mrs. W. H. Griffith, Mrs. Willard Kent, W. H. Griffith, Jr., Narragansett Pier, R. I.; J. H. Walsh, East Hartford, Conn.; Mrs. George K. Crandall, New London, Conn.; Mrs. Perry T. W Hale, Middletown, Conn.; Charles Whiting Baker of "Engineering News," Mrs. D. M. Gilbert, Mrs. F. W. Shepperd, Mrs. I. S. Holbrook, Mrs. Louis L. Tribus, Master Lucien Hall Tribus, Mrs. O. B. Mueller, Mrs. Chas. H. White, Edw. S. Cole, Mr. I. S. Holbrook of "Engineering Record," New York City; Mrs. C. E. Davis, Brown's Station, N. Y.; Mrs. Alexander Orr, Gloversville, N. Y.; H. A. Holmes, Waterford, N. Y.; Mrs. F. H. Luce, Woodhaven, N. Y.; Agnes Estes Reimer, East Orange, N. J.; Mrs. J. H. Cook, Mrs. Washington Paulison, Passaic, N. J.; Mr. C. E. Knowles, Mrs. Morris Knowles, Miss Helen Knowles, M. Knowles, Jr., Pittsburg, Pa.; Mrs. Wm. F. Woodburn, Philadelphia, Pa.; Mrs. C. W. Small, Washington, D. C.; R. Winthrop Pratt, engineer Ohio State Board of Health, Columbus, Ohio; Mrs. R. G. Wallace, Mrs. A. B. Mora, R. G. Wallace, Chicago, Ill.; Mrs. George A. Stacy, Marlboro, Mass.; Rev. W. S. Miller, Pittsburg, Pa.; Mrs. J. M. Birmingham, Miss M. E. Dwyer, Hartford, Conn.; Mr. George F. Whitney, "Hudson Contracting Co.," New York City.— 114.

[Names counted twice, — 4.]

TUESDAY EVENING, SEPTEMBER 11.

An informal "smoker" was held in the hotel parlor, to listen to a lecture on the White Mountains, by Prof. George N. Cross, illustrated by stereopticon.

WEDNESDAY, SEPTEMBER 12.

The opening session of the convention was held on Wednesday evening, Prof. William T. Sedgwick, President, in the chair.

Mr. Morris Knowles, chief engineer Bureau of Filtration, Pittsburg, Pa., was the first speaker. He gave a " Preliminary Description of the Pittsburg Filtration System," illustrated by stereopticon views. At the close of his address, President Sedgwick said:

" I think we have reason to be proud of this work which is going on in Pittsburg. We are most of us New England men, but we are Americans before we are New Englanders, and it has been a disgrace to our country for a number of years that the rich, powerful, and progressive city of Pittsburg, in the face of repeated warnings, and of universal knowledge of its condition, has gone on furnishing its people sewage-polluted water to drink. If at last it is to have an ample filtration plant, that may be some atonement, although at best it will have been installed too late to satisfy the friends of such as have died of typhoid fever.

" One cannot help being impressed with the tremendous progress which this subject of filtration has made in the past few years. When we think of the Lawrence filter, built in 1893, as the first of any consequence in the United States; when we think how few years have gone by since then, and remember what has been done in Albany and in Louisville and in Washington, and in many other cities and towns in the United States, and now in Pittsburg, we have reason to be very proud of the advances which are going on in water-works sanitation and construction. The time is fast coming when to furnish sewage-polluted water to a community will be regarded as an unpardonable crime, and when any city that continues to do it will be regarded as a city in disgrace.

" No one who has listened to Mr. Knowles can help feeling that here is a plan which has been studied out carefully, in which the possibilities of trouble have been foreseen, as far as any one can foresee them, and which shows an amount of progress which is most promising and interesting. I think we have occasion to rejoice, not only as members of the New England Water Works Association, but as American citizens, that the city of Pittsburg is likely to lose its disgraceful prominence in typhoid-fever statistics. For years every one who has studied typhoid fever in relation to water supplies has pointed out Pittsburg as one of the worst, if not the worst, among the big cities of the country, and that in the face of wealth, prosperity, and manufacturing intelligence such as the world has perhaps never seen in any other community of the same size. It is incongruous, it is an anachronism, that it should be so, and it is high time that Pittsburg, and all other cities which are now running on similar lines, should reform. That the work happens to be in charge of a member of the New England Water Works Association is to us a double cause for congratulation." [Applause.]

The next paper was by Mr. Carleton E. Davis, department engineer Board of Water Supply, New York City, and was a presentation of " Water Supply Problems on the Isthmus." This was also illustrated by stereopticon views. In presenting Mr. Davis, President Sedgwick said:

" The greatest piece of water-works construction that the world has ever seen, or is likely soon to see, is now in progress on the Isthmus of Panama, — the digging of the transcontinental canal. But although this is the greatest piece of work, there are connected with it many lesser pieces which are perhaps quite as interesting to us as water-works people. All the questions of water supply for the towns and cities on the Isthmus, for the laborers who must work on the canal or who must live there after it is built, are pressing problems which we Americans must meet; and many of them are new problems, because when the Suez Canal was dug engineers hadn't the ideas of the need of pure water that we have to-day, — water of any kind would do to drink then, — but to-day we want to dig our canal in the most honorable and scientific way, and we want the people who are digging it, and the people who are to live there afterwards, to have good water to drink. And here we can again congratulate ourselves, because Mr. Carleton E. Davis, one of our own members, was for a number of months engineer in charge of the water supply and sewerage problems along the line of the canal. He is now department engineer of the water supply of New York City, but he has kindly consented to have made for us some lantern slides illustrating local conditions on the Isthmus, and then to tell us about his own observations and experiences there. He has come to us to-night from New York for this purpose, as Mr. Knowles came from Pittsburg, and I have great pleasure in presenting him to you at this time." [Applause.]

At the conclusion of Mr. Davis's paper, which was illustrated by a number of interesting lantern slides, the meeting adjourned.

THURSDAY, SEPTEMBER 13, 1906.

The convention was called to order at 10 A.M. by President Sedgwick. The first business was the election of members. The Secretary read the following list of applicants, all of whom had been approved by the Executive Committee:

Resident. — Leon E. Scruton, Rochester, N. H., engaged in engineering and in installing water works; John H. Walsh, Superintendent East Hartford Fire District Water Works, East Hartford, Conn.; George A. Shackford, Water Commissioner, Reading, Mass.; Charles A. Bogardus, Superintendent Chicopee Water Department, Chicopee, Mass.; George H. Shaw, Filtration Engineer Springfield Water Works, Ludlow, Mass.; Freeland Howe, Jr., Norway, Me., Consulting Chemist and Bacteriologist; Henry W. Sanderson, Westfield, Mass., Superintendent Westfield Water Works; Charles A. Townsend, Water Commissioner, Rockland, Mass.

Non-Resident. — H. J. Fuller, Tacoma, Wash., Chief Engineer Tacoma Water Supply, Puget Sound Power Company, etc.; G. R. Coldwell, Brandon, Manitoba, Canada, Chairman Water Works Committee of Brandon.

Associate. — Hudson Contracting Company, cleaning water mains; The Pitometer Company, Chicago.

On motion of Mr. Collins the Secretary was instructed to cast one ballot in favor of the applicants, and, he having done so, they were declared elected members of the association.

The Secretary announced that the Executive Committee unanimously recommended the election of the following-named gentlemen as Honorary Members:

Joseph P. Davis, C. E., Yonkers, N. Y., — formerly City Engineer, Boston, — Chief Engineer of the Sudbury River Water Works, Consulting Engineer Metropolitan Water and Sewerage Board of Massachusetts, etc.

Dr. Henry P. Walcott, Cambridge, Mass., Chairman Massachusetts State Board of Health, member of Metropolitan Water and Sewerage Board of Massachusetts.

Hiram F. Mills, C. E., Lowell, Mass., Chief Engineer of Water Power at Lowell and Lawrence, member State Board of Health of Massachusetts, Consulting Engineer Metropolitan Water and Sewerage Board of Massachusetts.

Frederic P. Stearns, C. E., Boston, — formerly Chief Engineer State Board of Health of Massachusetts, — Chief Engineer Metropolitan Water and Sewerage Board, Consulting Engineer, President American Society of Civil Engineers.

John T. Fanning, Minneapolis, Minn., Consulting Engineer, builder of many water-works systems.

Rudolph Hering, New York City, Consulting Engineer for a great many sewerage and water systems, formerly member of New York Commission on Additional Water Supply.

E. D. Leavitt, Jr., Cambridge, Mass., Consulting Mechanical Engineer, designer of some of the most noted pumping engines ever built.

Edwin Reynolds, Milwaukee, Wis., Consulting Engineer, Allis-Chalmers Company, designer of the Reynolds Corliss engine and of the type of pumping engine built by the E. P. Allis Company and the Allis-Chalmers Company.

On motion of Mr. Charles W. Sherman the gentlemen whose names had been read were unanimously elected honorary members by a rising vote.

On motion of Mr. Sherman the President was requested to appoint a committee of five to nominate officers for the ensuing year. The President later appointed Messrs. Dexter Brackett,* of Boston; George C. Whipple, of New York; A. M. French, of Holyoke, Mass.; Leonard Metcalf, of Boston; and J. C. Hammond, Jr., of Rockville, Conn., as the committee.

The remainder of the morning session was devoted to practical experience papers. In presenting Mr. George A. Stacy, who headed the list of speakers on the program, President Sedgwick said:

" For a long time I have had the feeling that our association was a little bit in danger of getting papers in too large number which were scientific rather than immediately practical; and so I asked the Secretary, in arranging the program for the convention, to devote one of the best sessions, and if possible the whole of one session, to practical experience papers by members of the association, the idea being that if any member has a particularly interesting or difficult practical problem in which he needs the sympathy and help of his fellow-members, or in connection with which he is entitled to their congratulations for having succeeded in overcoming the difficulty, he should bring it forward so that we may all share in it. The Secretary fell in with the idea cordially, and the regular program for this morning provides for a series of such experience papers. I am sure that this feature will prove of great interest and value to many members of the association.

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* Mr. Brackett having declined to serve on account of ill-health, the President subsequently appointed Mr. George A. Stacy. of Marlboro, Mass., in his stead.

"It should always be a matter of pride with this association that it brings forward papers of great scientific importance, and thus shows the way for progress in all water-works affairs. I think the association has reason to be proud of the fact that it has had, from time to time, read before it, and published in its JOURNAL, so many papers which have embodied scientific progress. I think in this very convention we are having some of that kind, and I hope we shall have them in all of our meetings; but at the same time we want to remember that this is a practical association and that most of the members of it are interested in the difficult problems of daily administration. I hope the time will never come when we shall fail to recognize that fact, and to give to those men and to those problems due prominence. I am very glad, therefore, that we are to have this morning a number of papers pointing in that direction."

The first paper was by Mr. George A. Stacy, superintendent water works, Marlboro, Mass., his subject being "Trouble with a Check Valve."

The next paper was by Mr. Samuel A. Agnew, superintendent Scituate Water Works, North Scituate, Mass., entitled, "Pumping without Attendance." Mr. Frank L. Fuller, Mr. Daniel N. Tower, Mr. Freeman C. Coffin, and Mr. Wm. H. Thomas also spoke on the use of gasoline, gas, and kerosene engines. Mr. Sherman read a communication from Mr. E. H. Foster relative to pumping without attendance by a centrifugal pump driven by a Pelton motor, the latter receiving its power from the force main. Mr. A. A. Reimer gave an account of the experience at East Orange, N. J., with a centrifugal pump and electric motor which are in use at a substation there.

The next subject taken up was " Experiences with New England Water Works Association Standard Specifications for Cast-Iron Pipe and Special Castings," and the speakers were Mr. Charles W. Sherman and Mr. A. A. Reimer.

The report of the committee on " Uniformity in the Direction of Opening Hydrants and Gate-Valves and in the Size and Shape of Hydrant and Valve Nuts " was presented by Mr. Frank L. Fuller, chairman. The subject was discussed by Mr. M. F. Collins, Mr. Freeman C. Coffin, Mr. Alex. Orr, Mr. George A. Stacy, and Mr. Charles W. Sherman and Mr. Edmund M. Blake. The report was accepted as a report of progress, and the committee was requested to continue its work and report finally at some meeting during the winter.

At the evening session two papers, each illustrated by stereopticon views, were read, The first, by Mr. H. W. Spooner, engineer Water Department, Gloucester, Mass., was a description of the " Construction of a Subaqueous Tunnel at Gloucester "; and the second, by Mr. George H. Snell, water commissioner and superintendent water works, Attleborough, Mass., a description of " The New Reinforced Concrete Standpipe at Attleborough." Mr. Frank A. Barbour, of Boston, and Mr. L. C. Wason, president of the Aberthaw Construction Company, Boston, also spoke concerning the Attleborough standpipe.

FRIDAY, SEPTEMBER 14, 1906.

The convention met for its final session on Friday evening.

President Sedgwick read a paper, submitted by Mr. F. F. Forbes, superintendent water works, Brookline, Mass., entitled " Experiences in Introducing Compulsory Meterage, and Results Obtained by Metering All Supplies in the Town of Brookline, Mass."

The Committee on Meter Rates, through its chairman, Mr. Freeman C. Coffin, presented a progress report.

Mr. Joseph E. Beals, superintendent water works, Middleboro, Mass., read an experience paper entitled, " Homespun Device for Raising Pipe in the Trench."

Prof. Adolph Black, of Columbia University, New York, was elected a non-resident member.

A paper by Mr. George C. Whipple, New York City, on "The Cleveland Typhoid Fever Epidemic of 1903–4," was read by title, the discussions, if any, to be printed after the publication of the paper in the JOURNAL.

The President read the following letter, and announced that the editor would see that such portions of the various proceedings of the association as are available would be forwarded to Mr. Simin:

N. P. SIMIN, C. E.,
President of the Permanent Bureau of Russian Water Works Association.
RUSSIA, MOSCOW, Razgulay, 3.

The 12–25 June, 1906.

Mr. WILLIAM T. SEDGWICK, President of the New England Water Works Association, Boston, Mass.

Dear Sir, — Since 1893 we have had seven meetings of the Russian Water Works Association; their proceedings are printed in seven volumes. Moreover, our congresses have worked out a standard for cast-iron pipes and connection details, which are set forth in tables and drawings.

I address myself to you with a proposal to exchange publications and reports of the American and Russian associations.

At the same time I am addressing a similar proposal to the German, English and French associations, and I hope that my proposal of a relation of national associations will be welcomed.

If you consent to it, please give me an answer; I will then send all the printed matter of the Russian Association to the headquarters of the New England Association.

Yours very truly,

N. P. SIMIN,
President of the Permanent Bureau.

T. HALTURINE, *Secretary.*

The President announced that an invitation had been received to hold the next annual convention of the association at Norfolk, Va.

After calling Vice-President John C. Chase to the chair, President Sedgwick then spoke on the "Protection of Water Supplies from Pollution during the Construction, Maintenance, and Operation of Railroads; with Special Reference to the Water Supply of Seattle, Wash."

Mr. H. L. Weston, Committee on Exhibits, presented the following report.

REPORT OF COMMITTEE ON EXHIBITS.

As chairman of the Committee on Exhibits at the New England Water Works Association Convention at Fabyans, I desire to report that the following associate members made exhibits at the convention.

Ambursen Hydraulic Construction Company	Concrete dams.
Anderson Coupling Company	Brass goods.
Ashton Valve Company	Valves and gages.
Coffin Valve Company	Valves and hydrants.
Fairbanks Company	Gates and hydrants.
Garlock Packing Company	Packings.
Hart Packing Company	Packings.
Hersey Mfg. Company	Meters.
Jenkins Brothers	Valves and packings.
Lead Lined Iron Pipe Company	Lead lined pipe.
H. Mueller Mfg. Company	Brass goods.
National Meter Company	Meters.
Neptune Meter Company	Meters.
Pitometer Company	Pitometers.
Pittsburg Meter Company	Meters.
A. P. Smith Mfg. Company	Tapping machines, brass goods, etc.
Thomson Meter Company	Meters.
Union Water Meter Company	Meters.
R. D. Wood & Company	Valves, hydrants, and pipe.
Henry R. Worthington	Meters.

The number of exhibitors was not so large as at previous conventions nor the exhibits so extensive, notwithstanding the fact that some little effort was made to secure a good exhibition. This was probably owing to the fact that the convention as a whole was taken prëminently as a pleasure outing and the prevailing idea among the associate members seemed to be that exhibits were of minor importance.

Yours very truly,

H. L. WESTON.

Adjourned.

EXECUTIVE COMMITTEE.

On Steamer "Philadelphia,"
Boston Harbor, June 13, 1906.

Present: Vice-President Joseph M. Birmingham and Frank E. Merrill, Charles W. Sherman, Robert J. Thomas, L. M. Bancroft, and Willard Kent.

Mr. Merrill, member of committee on June meeting and September convention of the association, reported for the committee their action in relation thereto, recommending that the next annual convention be held at the White Mountains; whereupon it was

Voted: That the annual convention of the association be held at the White Mountains, September 12, 13, and 14, 1906.

After discussion of the question of transportation and hotel accommodations, it was

Voted: That Mr. Merrill be, and hereby is, empowered to make all necessary arrangements therefor and to act as transportation agent and conductor of the excursion in his own behalf.

Eight applications were received and recommended for membership, viz.:

Non-Resident Active: George Morgan Bacon, Salt Lake City, Utah; S. J. Rosamond, Fort Smith, Ark.; Robert J. Harding, Hudson, N. Y.; Charles L. Fox, Pittsburg, Pa.; A. W. Shaw, Brandon, Manitoba, Canada.

Resident Active: Gardner T. Swarts, M.D., Providence, R. I.; Charles E. Childs, Somerville, Mass.; E. C. Crosby, Brattleboro, Vt.

Adjourned.

Willard Kent, *Secretary.*

Tremont Temple, Boston, Mass., August 24, 1906.

Meeting of the Executive Committee of the New England Water Works Association.

Present: F. W. Gow, L. M. Bancroft, George A. Stacy, C. W. Sherman, Willard Kent, F. E. Merrill, John C. Chase. Vice-President Gow presided.

Voted: That the Committee on Convention be authorized to provide suitable entertainment for the ladies on one day of the convention, at the expense of the association.

Voted: That sessions of the association be held on mornings of Wednesday and Thursday, and on evenings of each day of the convention, the morning sessions to be subject to adjournment according to weather conditions.

Voted: That a " smoker " be held on the evening of arrival, Tuesday, September 11.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

FABYAN HOUSE,
FABYANS, N. H., September 12, 1906.

Present: President William T. Sedgwick and George A. Stacy, John C. Chase, Charles W. Sherman, James L. Tighe, Frederick W. Gow, Robert J. Thomas, Willard Kent, Lewis M. Bancroft, and Frank E. Merrill.

Thirteen applications were received and recommended for membership, viz.:

For Active Membership: G. R. Coldwell, Chairman of Committee Municipal Water Works System, Brandon, Manitoba, Canada; H. J. Fuller, Chief Engineer Tacoma Water Supply, Tacoma, Wash.; Charles A. Townsend, Water Commissioner, Rockland, Mass.; Henry William Sanderson, Superintendent Westfield Water Works, Westfield, Mass.; Freeland Howe, Jr., Chemist and Bacteriologist, Norway, Me.; George H. Shaw, Filtration Engineer Springfield Water Works, Ludlow, Mass.; Charles A. Bogardus, Superintendent Chicopee Water Department, Chicopee, Mass.; George A. Shackford, Water Commissioner, Reading, Mass.; John H. Walsh, Superintendent East Hartford Fire District Water Works, East Hartford, Conn.; Leon E. Scruton, Water Works Engineer, Rochester, N. H.; Adolph Black, Professor of Civil and Sanitary Engineering, Columbia University, N. Y.

For Associate Membership: The Pitometer Company, 310 Ashland Block, Chicago, Ill.; Hudson Contracting Company, engaged in cleaning water mains, 27 William St., New York City.

The following names were recommended for honorary membership:

Joseph P. Davis, Dr. Henry P. Walcott, Hiram F. Mills, Frederic

P. Stearns, John T. Fanning, Rudolph Hering, E. D. Leavitt, Jr., Edwin Reynolds.

The subject of annual convention for 1907 was discussed. An invitation from Norfolk, Va., was read; its acceptance, for various reasons, was not deemed advisable.

Washington, D. C., was suggested, and, on motion of Mr. Stacy, the subject was referred to the next meeting of the Executive Committee.

No further business appearing, meeting was adjourned.

Attest: WILLARD KENT, *Secretary.*

OBITUARY.

William W. Burnham died of typhoid fever, in Wilmington, N. C., on August 10, 1906.

Mr. Burnham was thirty-one years of age. He went from Biddeford, Me., in 1905, to act as engineer for the Carolina Trucking and Development Company, at Wilmington. He leaves a wife.

He was elected a member of the New England Water Works Association on September 13, 1905.

NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XX. December, 1906. No. 4.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

PUMPING WITHOUT AN AIR CHAMBER.

BY GEORGE A. STACY, SUPERINTENDENT WATER WORKS, MARLBORO,

ERRATA.

On page 352 of the JOURNAL for September, 1906, nine lines from bottom of page, for "Fort Fairfield" read "Fryeburg."

On the same page (352), seven lines from bottom, for "an adjoining town," read "Portland, about 50 miles distant."

the pump was working through 1 500 feet of force main directly up to the reservoir, and I did not know but it was possible that we could remove the air chamber and never notice the difference.

I had no occasion to try the experiment, however, until a few months ago, when word came from the pumping station that when they shut down and released the water from the pumps, through what we call the starting valve, the pressure was not reduced, and the water kept coming as evidence that there was something the matter with the check in the force main. On investigation, I found that one of the valves had broken. It was a three-ported

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PUMPING WITHOUT AN AIR CHAMBER.

BY GEORGE A. STACY, SUPERINTENDENT WATER WORKS, MARLBORO, MASS.

[*Presented September 13, 1906.*]

Some few years ago I was standing in our pumping station near a compound duplex condensing pumping engine of about three million capacity, with a friend of mine, who had had large experience in the designing and the management of pumping engines. Noticing the generous proportions of the air chamber on this particular pump, he made the remark that he believed that under the conditions under which that engine was working, the air chamber was not necessary, and was, in fact, practically worthless as regards any efficiency or smoothness of working of the pump. I paid no particular attention to it at the time, although it struck me as possible that it might be so, as we had begun at that time to do away with air chambers on boiler feed pumps, the boiler itself acting as the air chamber. In this case the pump was working through 1 500 feet of force main directly up to the reservoir, and I did not know but it was possible that we could remove the air chamber and never notice the difference.

I had no occasion to try the experiment, however, until a few months ago, when word came from the pumping station that when they shut down and released the water from the pumps, through what we call the starting valve, the pressure was not reduced, and the water kept coming as evidence that there was something the matter with the check in the force main. On investigation, I found that one of the valves had broken. It was a three-ported valve, built about twenty-three years ago, and the closing mechanism of the valves or ports was made of leather, — a type which you are probably all familiar with. To-day check valves of small size are sometimes made that same way. That is, the leather constitutes the covering for the valve-seat, being riveted to plates of iron to give stiffness, the joint or hinge being made by the leather between the plates; one which covers the opening and the other which is bolted to the body of the valve. The continual working of the valve for years weakening the leather, the one covering the middle port broke and dropped down. Not having leather I considered suitable to renew it with, we put the bonnet on the valve until such time as we could get it from the manufacturer of the valve, and went ahead with the pump without the check. Of course, the first day we had the air chamber charged as much as usual. In starting up the next morning, I told the engineer to go ahead with the pump all charged and the pressure on it, and if it didn't start up all right, to send for me. I will say, by the way, that I am responsible for the pumping engines on our works and all the mechanical details, and when anything goes wrong, I am supposed to be the doctor. The pump started all right with a full reservoir head on it, but in the afternoon of the second day I was called up and told that the pump wasn't working first rate. I went up to the pumping station and I found that at the end of the stroke there was a considerable jar. The pump had always worked very smoothly; as we say, it turned the corners quietly, but now you could see a marked change in the running. It was nothing very injurious, but it was rather annoying to an engineer; the noise was like discord to a musician. You would notice, as soon as you came within hearing of the pump, that there was something a little out of the usual, but, as I say, it was nothing dangerous, only it was unpleasant.

The next morning I went up to see if everything was running properly. The pump had started up all right again, but there was still this hammer at the end of the stroke. Across the street from the pumping station are one or two houses, and the principal of one of our schools lives in one of them. His wife came over and said she wished I would come over to the house and see if I could tell her what was the matter with the water pipe. She said she had had a plumber there the afternoon before, and about the time he went away the noise stopped, but that morning it was as bad as ever, so she was afraid perhaps he didn't understand his business and she wanted me to come over. I went over and the sound that I heard was what is familiar to most of us when the ball cock in a tank gets to vibrating, as it will sometimes under certain conditions, and we get that chug, chug, chug, all over the house. Of course when that is kept up incessantly all day long it would be rather annoying to a lady, or even to a man with strong nerves.

In my great wisdom I said at once, " Oh, I will fix that for you very quickly." I went to the water-closet tank, but I found everything quiet there, no vibration whatever. I asked where the tank for the hot water was, and she told me it was up in the attic, so we got a ladder and I crawled up through the scuttle-hole and brushed away the cobwebs and thought surely I would locate the trouble there, but to my surprise I could find nothing, and still this noise was going on. I thought less of my own wisdom at that time than I did when I started in. On coming down stairs I said, " How long has this been going on? " She replied, " It commenced yesterday, and I sent for the plumber and he came and worked all the afternoon and about the time he was going away the noise stopped, and he said he guessed it would be all right." I asked what time he went away, and she said about five o'clock. (That was about the time we stopped the pump.) I said, " Did it do this all night? " She said, " No; we didn't hear anything until this morning, when it commenced again. When we open the faucet we don't hear it." I went and opened the faucet and let a stream run about as big as my little finger, and the noise ceased; but when I closed the tap again, it would start up as before. I looked all around to see if I could find anything in the plumbing which would lead me to suspect a cause for that. Of course it flashed into my mind that the pulsations of our pump, in the absence of the air chamber, had given a new action to the water in the force main that it hadn't possessed before; but why it should set up a vibration in the service pipe to this house and not affect the service pipe to the next house, I didn't know. The service was metered, and the lady rather objected to letting the water run, but I wanted a little time to consider the matter, and I said, " You let the water run a little, and I will make it all right on the meter question, and if it continues to make a noise, let the water run more, and I think we will solve the trouble to-morrow, and you won't have any more difficulty."

On my way to the engine house I was thinking how I was going to remedy the trouble. It was simple enough. All we had to do was to shut the main gate on the force main, using the starting valve to discharge the water and relieve the pressure from the pump, and then in the morning use the charging valves to charge the pump the same as usual, and after getting the pressure equalized, gradually open the valve on the main and go ahead. We then had air enough in the air chamber to run part of two days before the water absorbed the air.

It came to me that an air chamber even under those conditions was of some use, and that if a man was offering me an engine and saying he would guarantee it to work all right without an air chamber, I should take exception to it.

We never had any trouble after that, but it is a mystery in my mind yet what caused the water hammer in that particular service and not in the adjoining one, when the services were exactly alike, except that this one was perhaps sixty feet longer. This incident brought to my mind that while theory is an excellent thing, practical experience is oftentimes a good deal better. And while this was not destructive, and wouldn't have prevented the continued action of the pump, it did prove to me that an air chamber is worth all it costs in preventing such conditions, even if they were not half as severe as these were.

This may seem to be a very simple matter, but it impressed itself on my mind as one of the little things which go to make up our life and bother us a good deal sometimes, and if we have the problem already solved, we haven't got to go and hunt up the solution of it.

DISCUSSION.

A Member. What kind of a pump was that?

Mr. Stacy. A Blake, just like all the tandem compound duplex condensing pumping engines, built about twenty-three years ago, of the old Worthington type.

Mr. Frank L. Fuller. I didn't exactly understand, Mr. Stacy, whether the air had been exhausted from the air chamber and after it was replaced there was no further trouble.

Mr. Stacy. I think very likely I didn't make myself plain on that point. On working the pump for the first day, you could see the water gradually creep up in the glass until the air was out of sight. Of course there was still some left, but the time came when the water absorbed all the air there was in the chamber, and we got a solid column of water, when, of course, the action of the air chamber was nothing, and at that time came the hard action on the pump and the water hammer in the house.

Mr. Fuller. I have had that same trouble in my own house at Wellesley. I think my house must be nearly two miles from the pumping station, and what seems rather to conflict with Mr. Stacy's statement or theory is that we have had that trouble early in the morning before the pump would be started. I have generally, by opening a faucet at the end of a long pipe in the cellar, cured the trouble for a while, and then perhaps in a month or two we would have it again. I had rather concluded it was due to an accumulation of air in the pipes in the house, but I never was certain of that, because on opening the faucet I never noticed any especial discharge of air. That word " chug " expresses it exactly.

Mr. Stacy. In relation to that, Mr. President, there is another little experience I had in this way. A man I have been acquainted with for many years said to me, " George, you say that a meter can't run unless water goes through it? " " Well," I said, " water or air or something of that kind; it doesn't run of its own volition." He owned considerable real estate and had a number of meters, and he said, " I have a meter which runs when there isn't any water or anything else running through it." I said, " I can't see that meter any too soon." So he said, " I will drive you up soon." It was just on the outskirts of the city, perhaps half a mile from city hall. I said, " Don't forget, because that is the biggest wonder I know of." He says, " I know what you believe, but that is the fact, and I will show it to you." I said, " All right." So it went along, and every afternoon or every time I met him I said, " I want to see that meter, but I don't want to go without you; I wouldn't miss seeing that meter for anything." He couldn't go then and it went for almost a week, when he met me and said, " George you needn't go." I said, " Why? " " Well," he says, " I have discovered what the trouble was. You said that no meter would run if we wa'n't drawing water, but we wa'n't drawing water at that place." The fact was that there was a long pipe which led out to the stable; the meter was in the basement of the hotel, and after shutting the faucet in the stable one day, he went and looked at his meter, and he saw the hand moving and it kept moving a little bit for some time. He rushed upstairs and couldn't find anybody drawing water, and he came back and the hand was still moving, and at last somebody opened and closed a faucet and it then stopped. He went and tried it again and it did the same thing, so he thought he had one of those wonderful things, a meter running with no water passing through it. The explanation was that way up in the attic, out of sight and hearing, except for what noise came through the piping system, there was a tank which supplied the hot-water system, with the usual ball cock attached, and the pipe running to the barn was long enough so that the water hammer on closing the faucet would counterbalance the ball on the lever; this water hammer and the reaction would cause the ball to vibrate, and a small amount of water would escape at each vibration, which was recorded by the meter. As he knew that nobody was drawing water in the house, he was thoroughly convinced he had found a meter which was actually going without any water passing through it. I only wish I had gone up there myself before he discovered it, and then I would have had the glory of solving the mystery.

THE NEW WATER SUPPLY OF THE CITY OF BROCKTON.

BY CHARLES R. FELTON, CITY ENGINEER, BROCKTON, MASS.

[*Read November 14, 1906.*]

Brockton is a city of about 50 000 inhabitants, chiefly engaged in the manufacture of shoes. Prior to 1903, water was taken from an artificial reservoir having an area of about ninety acres and a watershed of 3¼ square miles, and situated in the town of Avon. This water, while not unhealthful, was very highly colored, in some years averaging over .80, and in the lowest year never running below .48. The poor quality of the water, however, was not the primary cause for seeking a new supply.

The lowering of the reservoir to a depth of about seven feet below the rollway during the year 1899 led to the serious consideration of a new water supply, which had already received attention from Mr. F. Herbert Snow, formerly city engineer, and Mr. Horace Kingman, the superintendent of water works, who had made an excellent report. As the estimated quantity procurable from this source in a dry year was only 1 500 000 gallons per day, and our present average use of water is nearly 2 000 000 gallons, it is obvious that we moved none too quickly in the matter.

At this time the writer was asked to report all possible sources of supply to some expert to be selected by himself, and accordingly all available information was submitted to Mr. Desmond FitzGerald, of this society, and out of a large number of more or less desirable projects he reported most unqualifiedly in favor of Silver Lake. Even after this opinion was rendered, it was over a year before we were able to get the money appropriated to start on the work, the interim having been used in the discussion of the various schemes by the city government, where, curiously enough, a man's judgment on the question of water supply seemed to be quite largely influenced by his party affiliations, — almost all the Republicans seeming to believe that Silver Lake was the best place to go, and the Democrats seeming equally unanimous in the opinion that while there might be several other reliable sources, Silver Lake was certainly out of the question. Having finally completed the work, however, every one, even its bitterest opponents, seems to be well pleased, and at least two of them now point proudly to their names on the bronze tablet at the pumping station commemorating their achievements as members of the City Council.

The selection of this source, however, on account of its limited watershed, was to a certain extent dependent on the amount of water which was deemed requisite for a future supply, and to justify my somewhat radical conclusions as to the proper amount of water for a city to use, I am giving the following table, showing the consumption of water in Brockton for the last fourteen years.

TABLE No. 1. WATER CONSUMPTION IN BROCKTON SINCE 1892.

Water mains in 1892 = 43.74 miles; in 1905 = 97.366 miles.

YEAR.	Population.	Total Consumption (million gals.).	Daily Consumption in gals. per capita.	Domestic use in gals. per capita.		Manufacturing (gals. per capita).	Street Sprinkling (gals. per capita).	Fountains (gals. per capita).	Unaccounted for (gals. per capita).*
				Metered.	Un-metered.				
1892	29 643	271.6	25.0						
1893	30 817	264.4	23.5						
1894	31 993	323.2	27.7	6.7	3.8				
1895	33 165	399.6	33.0	7.3	3.2	2.4	1.8	1.5	16.8
1896	34 544	403.8	32.0	9.2	3.3	3.2	2.2	1.4	12.7
1897	35 923	386.4	29.5	8.5	2.6	4.0	2.8	1.4	10.2
1898	37 302	369.3	27.1	10.3	2.8	2.7	2.2	1.3	7.8
1899	38 681	414.7	29.4	11.0	2.7	3.6	2.6	1.3	8.2
1900	40 063	429.0	29.3	10.9	2.5	4.0	2.5	1.3	8.1
1901	41 610	447.5	29.4	11.5	2.1	4.0	2.4	1.4	8.0
1902	43 159	506.8	32.2	12.8	1.4	4.2	2.2	1.6	10.0
1903	44 704	537.8	33.0	13.5	1.4	4.9	2.1	1.6	9.5
1904	46 248	591.3	35.0	13.4	1.5	4.8	2.1	1.5	11.6
1905	47 792	621.4	35.6	15.3	1.6	5.1	2.3	1.7†	9.6

* Includes all use for flushing water and sewer pipes, fires, and slip of pumps.

† 16 fountains.

The somewhat rapid increase during the past year or two has been partially accounted for, and the consumption is now below 35 gallons per capita.

The rate of consumption per capita which it was assumed in 1901 would be used was as follows:

1905	35 gallons.
1910	37 „
1915	39 „
1920	41 „
1925	43 „
1930	45 „

or, in other words, it was assumed that we should never use over 45 gallons per capita.

While it may seem to many of you who have large per capita consumptions improbable that we shall be able to keep our consumption down to these figures, I would say that for the last five years we have been able at the *beginning* of the year to predict our consumption usually within one per cent. of the actual use, and always within five per cent. This, however, may have been and probably was due as much to good luck as good judgment. A monthly estimate of the water consumption for the year is made by the city engineer, based on the probable increase in population and legitimate use, and handed to the superintendent of water works; and any increase over this prediction is never considered as a legitimate increase in the consumption unless borne out by the meters or other reasonable cause, and an explanation is immediately sought by the superintendent, who last year found a leak amounting to over 200 000 gallons per day by examining the pipes under the bridges.

It is noteworthy that we have only one period of high consumption, namely, in the summer, whereas unmetered supplies commonly have a high period during the winter months.

The ratio of each month to the average monthly consumption as now used in these estimates is as follows:

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
.95	.90	.91	.87	1.08	1.12	1.18	1.13	1.05	.98	.88	.95

In view of our past experience, we did not figure on the necessity for such a large consumption of water as is usually considered advisable, believing that the provision of such extended works as would be required to furnish these large amounts of water would be unwise and unwarranted in our particular case.

Silver Lake is distant from Brockton City Hall, in a straight line, 11½ miles, and is situated in four different towns, viz., Halifax, Pembroke, Plympton, and Kingston. It is 644 acres in area, and has a maximum depth of 72 feet; its elevation above city base is 50 feet, and its total watershed, including water surface, is 4.4 square miles. Its shores are sandy, and soundings show no mud of any consequence within 25 feet of the surface. The total population on the watershed in 1897 was 50, or 18 to the square mile.

The area and storage capacity of the lake for each successive five feet is as follows:

Depth.	Area.	Storage Capacity in Million Gallons.
At high water	644 acres.	5 371
5 feet below high water	538 „	4 370
10 „ „ „ „	414 „	3 563
15 „ „ „ „	372 „	2 902
20 „ „ „ „	337 „	2 312
25 „ „ „ „	286 „	1 801
30 „ „ „ „	238 „	1 353
40 „ „ „ „	120 „	606
50 „ „ „ „	64 „	198
60 „ „ „ „	21 „	37
70 „ „ „ „	2 „	

On account of its immense storage capacity, in proportion to its watershed, it is obvious that the date at which we reach the amount of consumption which the watershed would supply continuously is not the date nor the consumption which the lake is capable of supplying, in figuring the date when more water will

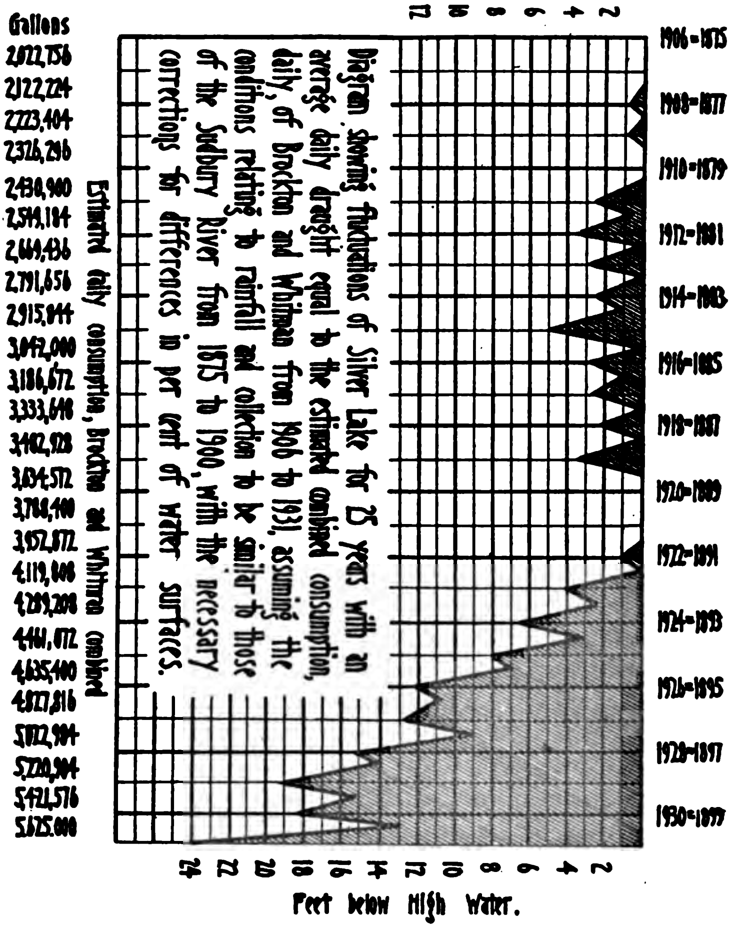

FIG. 1.

be required. Assuming that the next quarter of a century will have the same rainfall as the twenty-five years just passed, and basing our collection on the Sudbury River records, the above diagram, Fig. 1, shows that the lake would furnish us until the combined consumption of Brockton and Whitman is over 5 000 000 gallons per day, without drawing the water down over 16 feet, or till about 1930. The length of this period warrants the assumption that the next similar one will not be materially different, although the sequence of dry seasons may be materially changed. It will be noted in this particular case that if it were to be assumed that a watershed were good only till that time at which it ceased to fill every year, the limit of capacity would be reached in six years, while under our estimated probable conditions of increase we could go eighteen years without ever drawing the water down to a point where it would not rise within *two feet* of high water every year.

While it is estimated that the lake will furnish a supply for nearly twenty years, and never fail to fill to within two feet, or until the daily consumption is about 4 200 000 gallons, which is the amount that this storage would supply continuously, it would necessitate the drawing down of the water nearly 20 feet; and under the assumed conditions there would be many years when the lake would not fill. A draught of 3 500 000 gallons per day under the above assumptions would result as shown by the following diagram, Fig. 2, and during the predicted dry spell it would perhaps be best to use some water from the old supply, to make sure of the lake filling. While it might be somewhat optimistic to figure that this would occur exactly as figured, provided no other supply were at hand, with our old supply always ready we feel that we can risk our assumptions being practically realized.

While the water of the lake is practically colorless and tasteless at most times, we have a short period of about three weeks when there is taste and odor although no high color.

For the past six months, regular weekly, and at times semiweekly, chemical analyses and microscopical examinations of the Silver Lake water and of the several inlets to the lake have been made by Mr. George E. Bolling, our chemist and bacteriologist, and the following data are supplied by him.

The data afforded by the chemical analyses have indicated an absolute freedom from pollution from any animal sources.

The microscopical examinations have shown the presence of 33 genera at one time or other during the six months the water

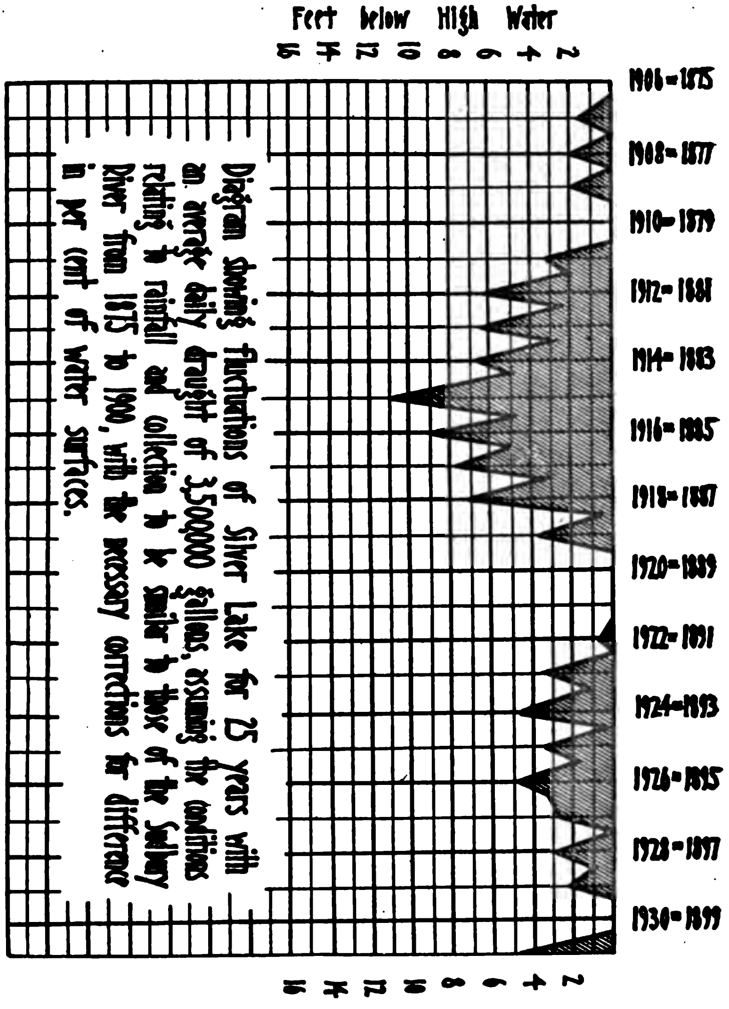

Fig. 2.

has been examined. Of these 33 genera, 18 were plants and 15 animals. Melosira has been by far the most abundant, reaching the number of 2 070 standard units per cubic centimeter on March

20, 1906. From this number it decreased steadily until June, when the organism was present to the number of 30 to 40 standard units per cubic centimeter. This diatom has invariably been present in all the samples taken from the lake, varying from 5 to 2 070 standard units per cubic centimeter. At the time of its greatest abundance, the turbidity of the water was reported as " slight " and the odor " faintly vegetable " in the cold and " vegetable " in the hot odor determinations, while the various data of the chemical analyses showed no change from the ordinary. No complaints whatever were received from consumers at this time.

The organism known as anabena appeared at the intake on July 10, to the amount of 139 standard units per cubic centimeter, having been detected in very small numbers in another part of the lake a few days previously. It had increased to 159 standard units per cubic centimeter by July 23, and then decreased to 17 standard units by August 1, and on August 6 none were found. Numerous complaints were received from consumers during this period, the process of disintegration undergone by the fragile organisms while subjected to pressure in the force main serving to liberate the odor peculiar to this species of algæ, so that it was readily appreciable in water drawn from the cold-water faucets, and greatly intensified and much more unpleasant from the hot-water faucets.

The first experience Brockton had with this troublesome plant was in 1905, during the first summer the new supply was used. At that time some of the dwellers near the lake asserted that the growth occurred only once in about every six or eight years, but its recurrence this summer would seem to indicate the probability of an annual visitation from the organism. At the time of its greatest abundance the odors reported on the samples taken from the lake were " faintly vegetable " in the cold and " distinctly vegetable, corn-silk " in the hot odor determination, but as has been indicated before, these odors were intensified during the passage of the water through the pipe system to the consumer.

Crustacea have invariably been present in small numbers in all of the samples examined.

Following is a table showing the average analyses of the water of Silver Lake for the past three years:

PARTS IN 100 000.

YEAR.	Color.	RESIDUE ON EVAPORATION.			AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Fixed.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
						Total.	In Solution.	In Suspension.					
1903...	.09	2.96	1.10	1.86	.0016	.0138	.0113	.0025	.60	.0007	.0000	.25	0.4
1904...	.10	3.01	1.30	1.73	.0013	.0143	.0123	.0020	.62	.0010	.0000	.27	0.6
1905...	.10	3.18	1.26	1.92	.0020	.0120	.0099	.0021	.61	.0019	.0000	.22	0.6

THE FORCE MAIN.

The great length of the force main, and a difference of about $100 000 in the cost between the various trade sizes of iron pipe at about the probable limits of reason, viz., 20-inch, 24-inch, or 30-inch pipe, involved some very interesting work which space will hardly allow me to enter upon, as the various elements affecting the choice of a size would make a paper of reasonable length in themselves. Suffice it to say that for the 11½ miles of force main a 24-inch pipe was selected, rather than a 20-inch or a 30-inch, and fulfilled the conditions nearly enough to render it unnecessary to attempt a special size between the usual trade sizes.

As a rule in the streets the top of the pipe was laid about 4 feet below the surface; over private land about 3½ feet was usually sought, although we have some stretches of considerable length where the pipe is not covered over 18 inches. One course which we adopted, although not usually followed in pipe laying, was the filling of the joints inside of the pipe with Portland cement. My chief object in doing this was to reduce friction by adding to the interior smoothness. I figured that a reduction of 3 feet in the friction head would pay for the cost of doing the work. A careful friction test of the pipe since that time does not show conclusively that the friction was materially reduced, as it was almost exactly what is given in Weston's well-known tables for new pipe. This pipe was from one to three years old, however, at the time of the test, but other friction tables give much lower friction rates than Weston's.

In the trench with the force main was laid a 6-wire lead cable for the telephone service and the Winslow recording apparatus. This cable was placed in a 1½-inch wrought-iron pipe, largely old pipe secured from the junk man.

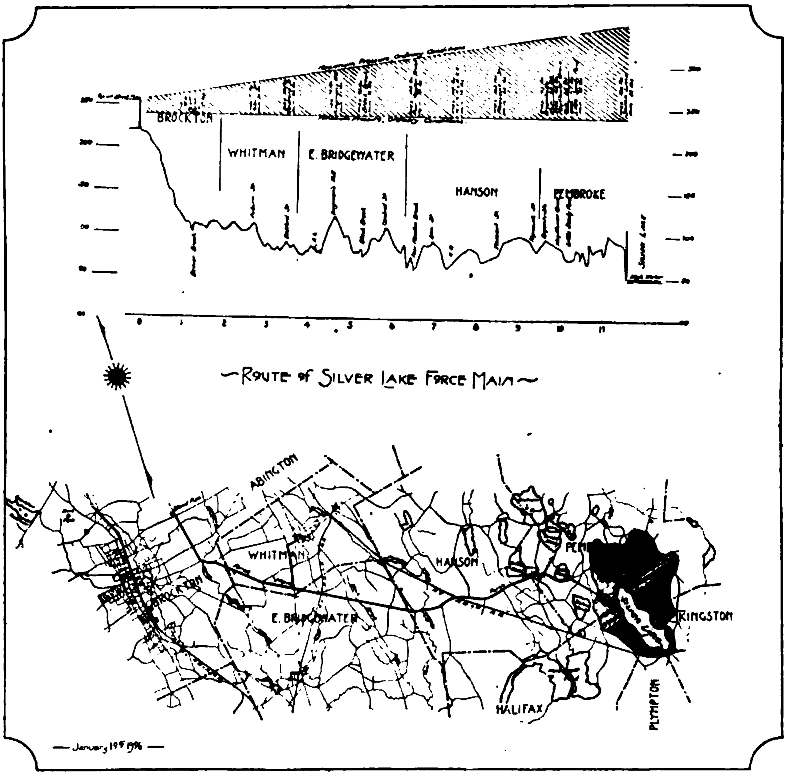

FIG. 3.
Scale of Plan, about 5 miles to an inch.

Air valves were placed on the main at all the summits, there being 22 on the line. We decided not to put in automatic air valves, but to send over the line occasionally and open them up. They consist simply of a regular 1¼-inch corporation and open-way valve, with a pipe running up nearly to the surface of

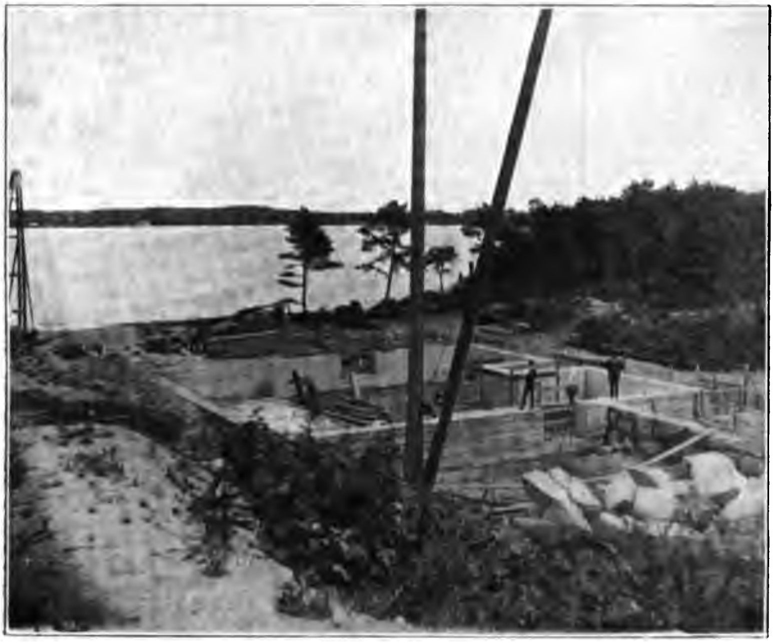

FIG. 1. FOUNDATION, SILVER LAKE PUMPING STATION.

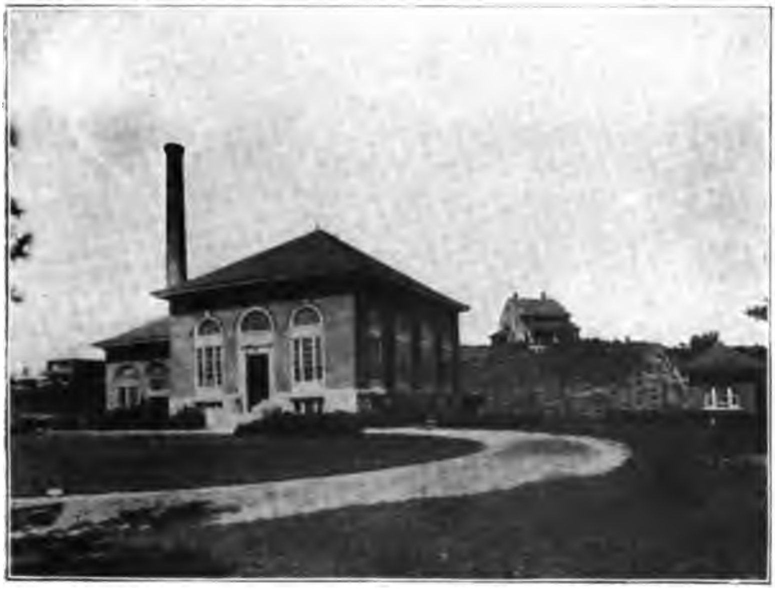

FIG. 2. SILVER LAKE PUMPING STATION.

the ground and a gate box over the pipe. A recent opening of all the valves after three months' operation showed no air in any summit except the one nearest the pump, where there was a very considerable amount, taking about one and one-half minutes to expel it before we got any water.

It may be interesting to state that the pump has been in operation over a year, under a pressure as high as 160 pounds, and that it has been necessary to remove only one cracked pipe; no joint leaks have yet been discovered, one joint leak having been recalked before the pump was started.

LEAKAGE IN THE FORCE MAIN.

There being but very little published information on the actual leakage in water pipes, it was decided to test this leakage in the force main.

As the pipe was laid from Brockton towards Silver Lake, it was possible to turn the water in as soon as the work was completed. A by-pass of 1-inch pipe with a ⅝-inch disk meter was placed on the 24-inch main at a 24-inch gate, and the gate was closed here and at the end of the construction. The total distance was 22 476 feet, and the following observations were taken: From August 31 at 2.15 P.M. to September 1 at 7 A.M., about nine hours, the leakage was at the rate of 285 gallons per day; from September 1 at 7 A.M. to September 13 at 12 M., about twelve days, the leakage was at the rate of 277 gallons per day; the latter being at the rate of 65 gallons per day per mile of 24-inch pipe under an average pressure of 68 pounds. There had then been added 3 334 feet of pipe, making the total length 25 810 feet. The gate was opened and the following results were observed:

Average for first 2¼ days, the meter showed 100 gal. per day per mile.
,, ,, next succeeding 1¾ days, 82 ,, ,, ,, ,, ,,
,, ,, ,, ,, 4 ,, 58 ,, ,, ,, ,, ,,
,, ,, ,, ,, 13 ,, 32 ,, ,, ,, ,, ,,
,, ,, ,, ,, 50 ,, 20 ,, ,, ,, ,, ,,

The noticeable decrease may have been due to the stopping up of minute leaks, or possibly to the compression or expulsion of air in the summits.

After this it became inconvenient to make further tests; but desiring to get a test on the whole line, 61 000 feet in length, in combination with a friction test, after the pumps had been running about a year, all gates leading from the main were closed and observations were taken of the lowering of the water in the standpipe. This necessitated closing about 50 services, and about 50 other gates, comprising sizes 6-inch, 8-inch, 12-inch, 16-inch, and 24-inch, with one house service open. This indicated a leakage of 285 gallons per day per mile, under an average pressure of 71 pounds. While this does not show conclusively that the leakage in the force main was not less than 285 gallons per day per mile, it shows that it was not more than that.

A pipe wagon, designed by the superintendent, Mr. Kingman, is shown in the accompanying photograph. This apparatus is very quickly loaded and unloaded, and allows a pipe to be conveniently dropped at any point.

PUMPING ENGINE ECONOMY.

In the selection of the necessary duty to be specified for the pump, the following table was used, it being an adaptation of a table published by Mr. Coggeshall in a former JOURNAL,* the difference being that a unit system has been used so that it may be applied to any conditions, the rate of interest has been changed, and a life for the pump of twenty-five years has been assumed, which makes the figures materially different from those where interest alone is considered. From this table it is obvious that under our circumstances it was economical to pay a large sum for high duty, and in our particular case we offered a bonus of $350 per million for duties above 150 million, with a penalty of $500 for every million below 150.

TABLE No. 2. — ANNUAL COST OF COAL FOR PUMPING 1 000 000 GALLONS OF WATER DAILY TO A HEIGHT OF 100 FEET, WITH COAL AT $5.00 PER TON (2 000 LB.).

This table gives sums the interest of which at 3½ per cent. represents the saving effected by pumps of superior economy over an inferior one, assuming the life of the engine at twenty-five

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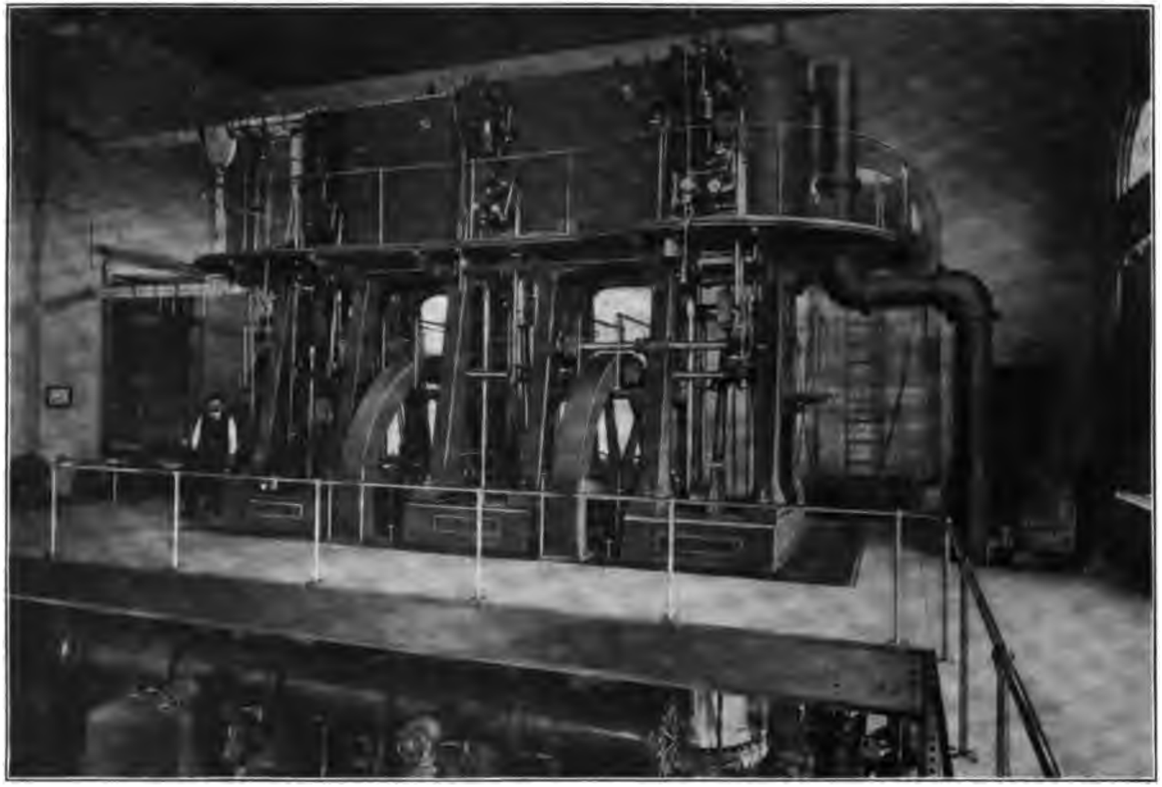
* Vol. II, p. 240, June, 1897.

PLATE II.



BARR PUMPING ENGINE IN SILVER LAKE PUMPING STATION.

years, and establishing a sinking fund at 3½ per cent. interest to retire the first cost of pumps at that time. The table may be used in direct proportion for other heights, for other consumptions, or for other prices of coal.

Lower Duty.	Yearly Cost of Coal.	Higher Duty in Million Foot Pounds per 100 Pounds of Coal.									
		150	140	130	120	110	100	90	80	70	60
50	$1 522	16 920	16 300	15 600	14 800	13 830	12 680	11 270	9 517	7 250	4 233
60	1 268	12 680	12 070	11 380	10 570	9 600	8 450	7 030	5 283	3 020	
70	1 087	9 670	9 050	8 370	7 550	6 580	5 430	4 020	2 270		
80	951	7 400	6 780	6 100	5 280	4 320	3 170	1 750			
90	846	5 650	5 030	4 350	3 530	2 570	1 420				
100	761	4 230	3 620	2 930	2 120	1 150					
110	692	3 080	2 470	1 780	970						
120	634	2 120	1 500	820							
130	585	1 300	650								
140	544	620									
150	507										

Note. — Select the column headed by the higher duty. Then select the line beginning with the lower duty. The sum found at the intersection of the column and line is that which, under the above conditions, could be paid for the higher duty engine above the price of the lower duty engine.

PUMPING STATION BUILDING AND CHIMNEY.

The pumping station is well shown in the accompanying photographs. It is of red brick, the foundations of the pump room being of Portland cement concrete and of the boiler and coal room of granite. The pump, boiler, and chimney foundations are of concrete. The pump foundations extend four feet below the floor and are designed for a load of about one ton to the square foot, as are all the other foundations. This seems a very light load, but the material upon which we constructed was of a fine, wet, quicksandy nature, containing clay, and very unstable when unconfined. Space has been left for another pump, which would now be only for purposes of duplication, as it would be impossible to use the two in conjunction on account of the excessive friction head, although the size of the duplicate might be somewhat increased.

The chimney is of radial brick, 100 feet high, with an inside diameter of four feet at the top, there being no interior core above the common brick base 20 feet in height; this base is lined with radial brick of the same class as those in the chimney.

The boiler room contains two 264 horse-power water tube boilers built by the Aultman-Taylor Company. They are of the well-known type made common by the Babcock & Wilcox Company, and are insured to carry 160 pounds of steam. The coal room is 40 feet square and arranged to get the coal in at the top. A Green Economizer, to utilize the flue gases, is installed behind

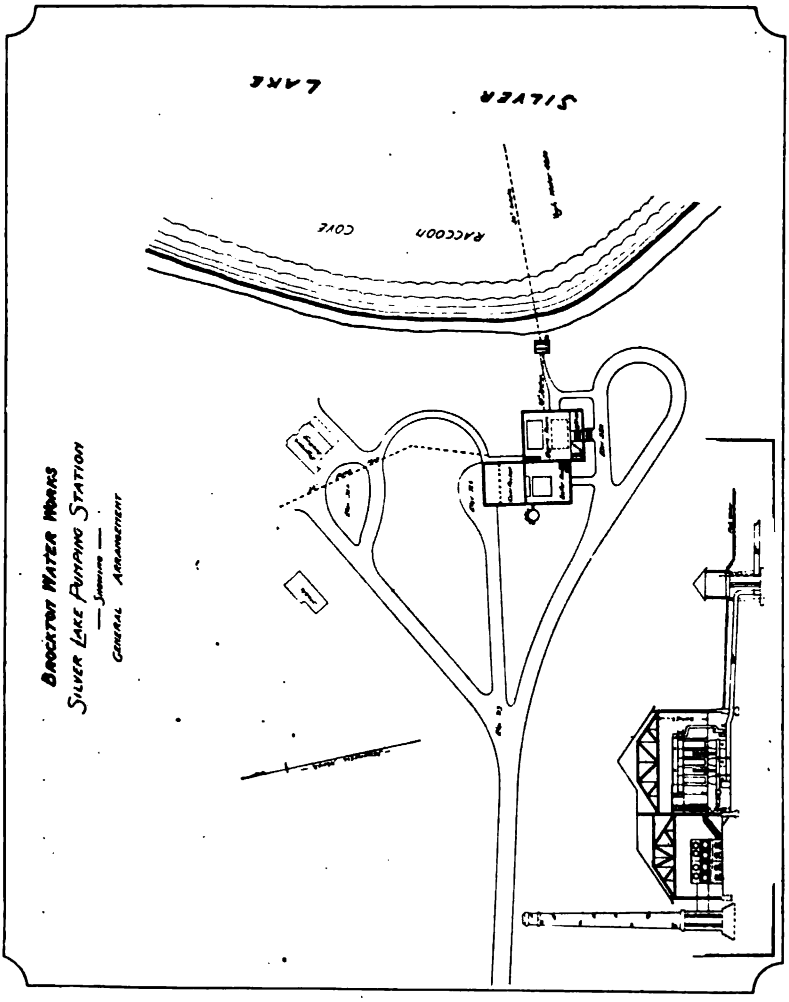


FIG. 4.
Scale of Plan, about 200 ft. to an inch. Scale of Cross Section about 100 ft. to an inch.

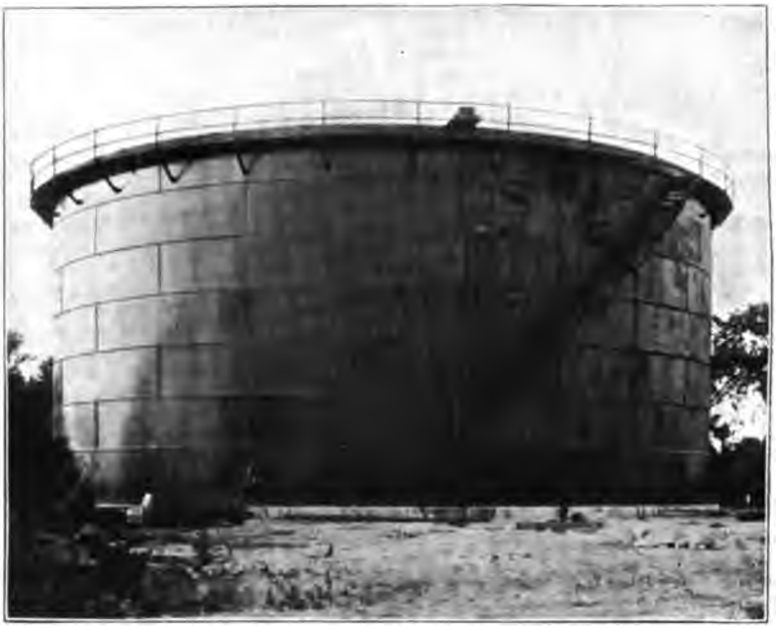


FIG. 1. NEW BROCKTON STANDPIPE.

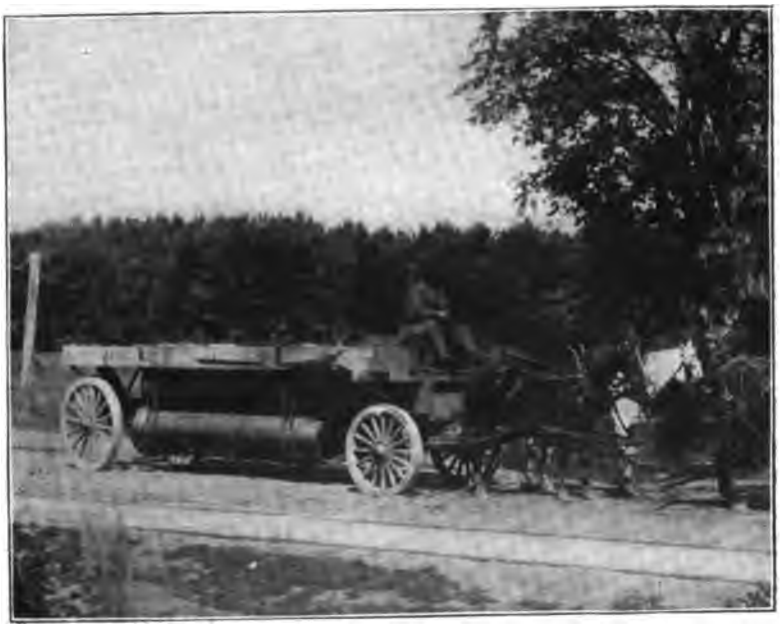


FIG. 2. PIPE WAGON.

the boilers, and heats the water about 100 degrees from about 90 degrees under ordinary conditions.

The pumps were furnished by the Barr Pump Company, and have a nominal capacity of 6 000 000 gallons per day. They are of the well-known vertical, triple expansion, crank and fly-wheel type, with cylinders 22, 36, and 59 inches in diameter, and three 19-inch water plungers, of 36-inch stroke. The valve area is 150 per cent. of the plunger area. The boiler feed pumps and air pump are attached to the low-pressure crosshead and have the same stroke. Condensing is done by a jet condenser. The steam cylinders are jacketed on the barrels, and the valves, of the Corliss type, are located in the heads; there are reheaters between the cylinders. The independent boiler feed, electric lighting generator, air compressor for cleaning boiler tubes, the repairing machinery and Green Economizer are all run by a small water motor discharging back to the lake.

The principal results of the duty test were as follows:

Principal Results.

Duration of trial, 10.30 A.M. to 8.30 P.M.	10 hours.
Total number of revolutions, by counter	20 118
Average revolutions per minute	33.53
Length of stroke, in feet	3 feet.
Average number of feet per minute piston travel	201.18

Temperatures.

Temperature of feed water	66°
Temperature of outer air for day*	71°
(Minimum, 56; maximum, 84.)	

Feed Water.

Total weight of water	46 753 pounds.
Leakage from boilers	375 pounds.
Total amount of water used by engines	46 378 pounds.

Pressures.

Steam pressure at throttle, by gage on engine	150.1 pounds.
(Corrected for water column.)	
Barometric pressure	14.61 pounds.
Absolute pressure	164.71 pounds.
Vacuum	25.8 inches.
Pressure by test gage on force main	119.5 pounds.
Difference between center of gage and water in pump well	20.9 feet.
Total water pressure (head)	128.6 pounds.

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* At Brockton.

Duty, — Basis of 1 000 *Pounds of Steam (Plunger Displacement).*

$$850.5861 \frac{(128.6 \times 3 \times 20\,118 \times 1\,000)}{46\,378} = 142\,348\,630 \text{ foot-pounds.}$$

Capacity based on plunger displacement = 6 400 500 gallons per day.

A slip test of these pumps, using one of Mr. J. R. Freeman's calibrated 4-inch nozzles at a rate of about 5 200 000 gallons per day, indicated as lip of 2.8 per cent. (the fluctuations of the mercury column are well indicated by the following diagram, Fig. 5), and a later test made by pumping into the 75-foot diameter standpipe showed 2 per cent. slip, after allowing for leakage in the force main.

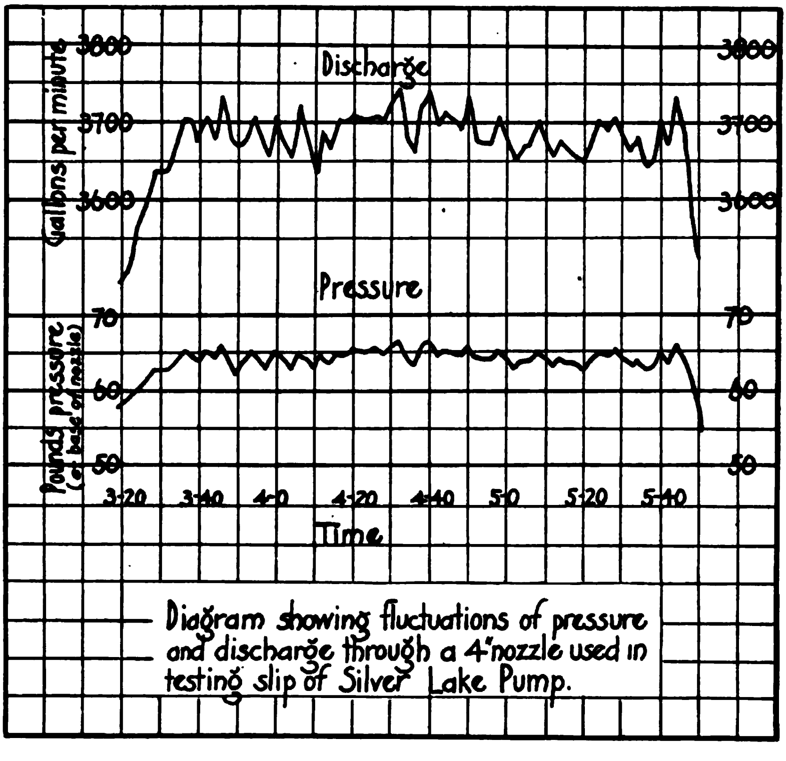

FIG. 5.

SCREEN HOUSE AND INTAKE.

The screen well is 12 feet in diameter, with a double set of ¼-inch screens in grooves, and is situated about 50 feet from the pumping station. This well presented the most difficult problem of all our work. Three-inch tongued and grooved sheeting was driven before digging began, and extended about 12 feet below the bottom of the well; the material was a fine quicksand, and boiled up nearly as fast as it could be removed, settling the ground to a distance of 50 feet in some directions. The intake pipe is 30 inches in diameter, is laid level, and extends 225 feet into the lake. Owing to our experience with the pump well, we did not attempt to pump out the sheeting in the lake, but excavated between the sheeting with a small orange-peel bucket and stiff-leg derrick, floated the last section of the pipe — 156 feet in length — which was headed up with wooden heads, and sank the pipe by admitting water through rubber tubes, it being necessary to excavate and make one connection where the two sections joined. The end of the pipe rests on a concrete block about 3 feet above the bottom.

STANDPIPE AND PRESSURES.

The need of more storage capacity led to the construction of a new standpipe 75 feet in diameter and 35 feet high, with spiral stairway and balcony.

The top of the new standpipe is 3 feet 4 inches higher than the old one, and their combined capacity is about two and a half million gallons, or (which is more important, as we seldom allow them to go down over 15 feet and never more than 20 feet) about 55 000 gallons per foot.

The highest part of the city is at an elevation only about 12 feet below the top of the standpipes, but the high portion is very limited in population, and we have a static pressure of 50 pounds on over 70 per cent. of the hydrants, only 6 per cent. having less than 30 pounds, with about 4 per cent. over 70 pounds. A much higher pressure would, of course, be desirable.

The construction of the standpipe presents no unusual features. It has concrete foundations 3 feet thick, projecting 1 foot above the surface of the ground. It is constructed of mild steel having a tensile strength of 54 000 to 62 000 pounds per square inch. The work was done with a pneumatic gap riveter. It is composed of seven courses of plates, with lap seams.

The following table gives the thickness of plates and pitch of rivets, all horizontal seams being single riveted; there is a $6 \times 6 \times \frac{11}{16}$-inch bottom angle on the *inside*, and a $3\frac{1}{2}$ x $3\frac{1}{2}$ angle iron on the outside, 18 inches below the top. It is designed for unit strains of 13 500 pounds per square inch on the plates, and 9 000 pounds on the rivets, which are of steel. The bottom is $\frac{1}{2}$-inch thick.

	Thickness of Plate.	VERTICAL RIVETING.		
		Rows.	Size.	Pitch.
Course 1........	$\frac{11}{16}''$	triple	1″	3.71″
„ 2........	$\frac{5}{8}''$	„	$\frac{7}{8}''$	3.14″
„ 3........	$\frac{1}{2}''$	„	$\frac{3}{4}''$	2.83″
„ 4........	$\frac{7}{16}''$	double	$\frac{3}{4}''$	2.38″
„ 5........	$\frac{3}{8}''$	„	$\frac{5}{8}''$	2.29″
„ 6........	$\frac{5}{16}''$	single	$\frac{5}{8}''$	1.70″
„ 7........	$\frac{5}{16}''$	„	$\frac{5}{8}''$	1.70″

The standpipe is equipped with the Winslow recording apparatus, run by a float in an 8-inch pipe resting on but not secured to the bottom of the standpipe. The 8-inch pipe is 4 feet from the side of the standpipe, and is held in place by two brackets, one at the top of the standpipe and the other 12 feet from the bottom, the latter being below the intended low-water mark. The 8-inch pipe is perforated by a small hole about 2 feet above the bottom, and has about 3 feet of oil in the top of the pipe to prevent freezing. The movement of the float is perfectly steady and is apparently absolutely unaffected by surface fluctuations.

The cost of the standpipe erected, with stairway and balcony, including two coats of paint, was $10 550. The cost of the foundation, including excavation, was $3 209.49.

Four bids for a concrete-steel standpipe, based on the designs of the bidders, were submitted, and the bids ranged from $15 500 to $19 000. The lowest bid was received informally after the others were opened; had it been before us at the opening, it is a question whether we should not have accepted it.

Owing to a strong local feeling, and not to any particular prejudices of the writer, the whole work, with the exception of the chimney and standpipe, including the erection of the buildings, was done practically entirely by city labor, the laborers being paid $2.25 per day of eight hours. This work was under the sole charge of Mr. Horace Kingman, the superintendent of the water works, and was ably carried through within the original estimates, in spite of the high cost of pipe.

DISCUSSION.

MR. DESMOND FITZGERALD. I came here to-day, Mr. President, to listen rather than to speak, and it is needless to say that Mr. Felton's paper has proved interesting. In connection with the Brockton work I remember after making my report I received an invitation to spend an evening with the mayor, aldermen, and common council to answer any questions they might see fit to propound. You may imagine there were some questions asked which were somewhat embarrassing. Among them I remember this: " You recommend taking water from Silver Lake, which is 14 miles away. Now, sir, suppose there was a river of pure water directly under the city, flowing away in large quantities; would that be a sensible thing to do? " Well, what kind of an answer could a man make to that question? Naturally, it would be a very short one, that it would be a very foolish thing to do. I afterwards was informed that a certain learned professor in Harvard had stated his belief that one of those underground rivers we hear about so often was running under Brockton to the sea, and all they would have to do to get a supply of water there would be to drive a pipe down and tap it. [Laughter.] It is a fact that this supposed stream kept action on Silver Lake in abeyance for several months.

I think that Brockton is very fortunate in having such a fine source of supply as this lake. I remember the clearness of the water and the sandy beaches around the border. It seems to me that, so far as the quality of the water is concerned, there are few cities or towns as fortunate.

I have made a great many active enemies in my life, I am afraid, but among the most active I recall now is the old anabena. He has attacked the Boston water supply several times and so vigorously that a person could not take a bath in the water with any pleasure, and no one would venture to use it in brushing his teeth. We didn't know much about him at that time, but we came very closely in contact with him and found good reason for shunning his acquaintance. I am, therefore, very much pleased to learn that the source of water supply I recommended to Brockton has only reached 128 per cubic centimeter. What would the people have thought if the number instead of being 128 had been 1 028 as I have frequently seen?

Mr. Morris Knowles. I was especially interested in Mr. Felton's remarks about using second-hand pipe for laying the cable. We are laying considerable cable ourselves, and where we are not able to lay a tile conduit we have used tubing, understanding that it would be very difficult to draw a cable through pipe on account of their not being smooth at the joints. I should like to ask Mr. Felton how far apart the drawing-in manholes were, and if he experienced any trouble from injury caused in drawing-in.

Mr. Felton. No; we had no difficulty whatever, and never discovered that there was any mechanical injury to the cable. The drawing-in stations were about 500 feet apart. We thought of the possibility of injury and considered seriously whether we shouldn't lay the cable without any covering, except in the streets. There is quite a large portion of the line over private land and through woods, and the pipe is only to prevent mechanical injury. When we first got the thing finished, as we thought, we couldn't make it work for a while. We suspected it was the fault of the man who made the joints, so we had some one go over the line and inspect them, and he found some that were weak; it was claimed water had got into them, and since they have been made right it has never failed to work in good shape. The recording apparatus has worked satisfactorily, although we have a little trouble with the float on account of the lengthening of the string. It is supposed to record every 3 inches, and it hasn't been more than 9 inches out at any time, but it has been as much as that. We can't depend upon it within 6 inches, on account of the float slipping on the wheel or possibly a little slipping of the string.

Mr. FitzGerald. I should like to ask what the nozzle pressure of that 4-inch stream at the lake was.

Mr. Felton. The nozzle pressure was about 62 pounds and the pressure at the pumps was about 140, the difference being lost in friction.

Mr. FitzGerald. What was the horizontal distance of the stream above the lake?

Mr. Felton. I am sorry to say we didn't get a good measurement of that, and I can only judge by the photograph. I should say the bulk of the stream was very nearly 200 feet, but it broke up a good deal, as you noticed in the slide, giving a very beautiful effect, with rainbows, etc.

A STUDY OF SOME VITAL STATISTICS.

BY L. M. HASTINGS, CITY ENGINEER, CAMBRIDGE, MASS.

[*Read November 14, 1906.*]

Nature has implanted in every sane person a desire to live, to prolong life, and pursue, as far as possible, health, and the capacity for enjoyment. The old story of Ponce de Leon seeking the fountains of eternal youth but illustrates the real desires of every human being, and typifies, in its story of search and struggle and final disappointment and defeat, the ceaseless effort of the human race to find some way by which the dread ravages of disease may be averted and the relentless hand of death stayed.

While the fabled " Fountain of Eternal Youth " has never been discovered, nor that magic potion which it was believed should forever preserve health and beauty been compounded, — at least in any such manner as the ancients thought possible, — nevertheless very much has been done in these later years not only to lengthen the average of human life, but to increase its capacity for productive work and enjoyment. Of the many causes which have tended to produce this result, perhaps the two most prominent are the marvelous progress made in medical discovery in the knowledge of the causation of many diseases, with an increased efficiency in its prevention or cure, and in sanitary science a far better understanding of the effect upon health of environment, — soil, climate, temperature, cleanliness, drainage, etc., — and the hygienic value of good food, water, and air.

In the field of medical discovery the most potent factor in producing the remarkable results obtained is the work of highly trained specialists and experimenters in natural and medical science. It would be difficult to overestimate the debt which the world owes to these scientific men who, by patient investigation and research, extending often through long years of poorly paid labor, have made discoveries and established theories the application of which will be of incalculable benefit to mankind. This is all the more noteworthy because in many cases the amount of laborious experiment and research necessary to establish a single fact of importance is enormous, and the degree of scientific skill and intelligence required the highest.

Think, for instance, of the time and labor and patient investigation required to discover and demonstrate — what is now generally accepted as correct — the general theory of the germal origin of many diseases. How can the world repay Robert Koch, of Germany, who, perhaps more than any other one man, advanced the knowledge of bacteriology in its relation to disease, or Louis Pasteur, of France, who developed the method of cultures of these bacteria so that they could be readily examined or studied, and later discovered a remedy for that terrible malady, rabies, or hydrophobia, so that the mortality from the disease has been reduced from 60 to 80 per cent. to less than 1 per cent.?

Think of the work of Klebs and Löffler in Germany, in determining the bacteria of diphtheria, and of Behring in Germany and Roux in Paris in perfecting the antitoxin treatment for this terribly fatal disease, saving thousands of otherwise doomed victims.

As a result of the labors of these and a great many other men — physicians, chemists, bacteriologists, biologists, sanitary engineers — who have devoted themselves unselfishly to the cause of bettering humanity on its physical side, we have to-day advanced far on the road to a proper understanding of disease, its cause, prevention, and cure. We have also, in many ways, a far better and more rational standard of living than before; better food, better houses, purer water, and better sanitary conditions in cities and crowded areas. One of the most striking demonstrations of the efficiency of this increased knowledge concerning disease of which we have been speaking is the decreased number and virulence of the outbreaks of contagious diseases and their greatly lessened mortality; smallpox, yellow fever, cholera, diphtheria, the plague, and similar diseases, have now no such terrors as formerly.

Another evidence of the practical value of this increased knowledge of sanitary and medical matters is a *lowered annual death* *rate.* I believe that this result is pretty general throughout this country; it certainly appears in the statistics which I have examined, being most marked in the last decade, and especially in the *cities.* Now this lower annual death rate indicates a *longer average life* to the individual, with all its possibilities for enjoyment and for usefulness to the community. It also indicates a lessened *morbidity* or sick rate, with its burden of expense and lessened earnings.

Another fact worthy of notice is that this lowering of the death-rate has been largely among the *young,* or persons under five years of age, with the expectation of a long life before them. As will be shown, the greatest mortality occurs among the very young, and decreases as the age advances until about the fifteenth year, when the death-rate begins to rise again. If, therefore, the young can be carried over this period of greatest danger, their expectancy of life will be greatly increased.

It is to the credit of the new knowledge that this is exactly what has happened. The average annual death rate in Cambridge among children under five years of age for the thirty years from 1850 to 1879 was about 9.00 per 1 000 of all persons living, while for the ten years 1894 to 1903 it was only 6.08 per 1 000, a decrease of about 33 per cent.,— a very excellent showing.

The figures which I have prepared relate largely to Cambridge, but I think that in a general way the results are typical of those which obtain in cities in many parts of the country. Free use has also been made of the statistics given by Mr. Robert Moore in his excellent paper on " Vital Statistics of St. Louis since 1840," published in the *Journal of the Association of Engineering Societies,* November, 1904. They are used simply as an interesting comparison between localities remotely situated.

Climatic conditions, as indicated by temperature and rainfall, have an important effect on health and happiness, and so Fig. 1 is given, showing the precipitation and average temperature readings at New Bedford, Mass., 1813–1904. These are said to be the longest and most reliable set of meteorological observations taken in New England, being made entirely by Mr. Samuel Rodman and son for the time 1813 to 1904. A study of this plate would seem to show that while there has been some variation of

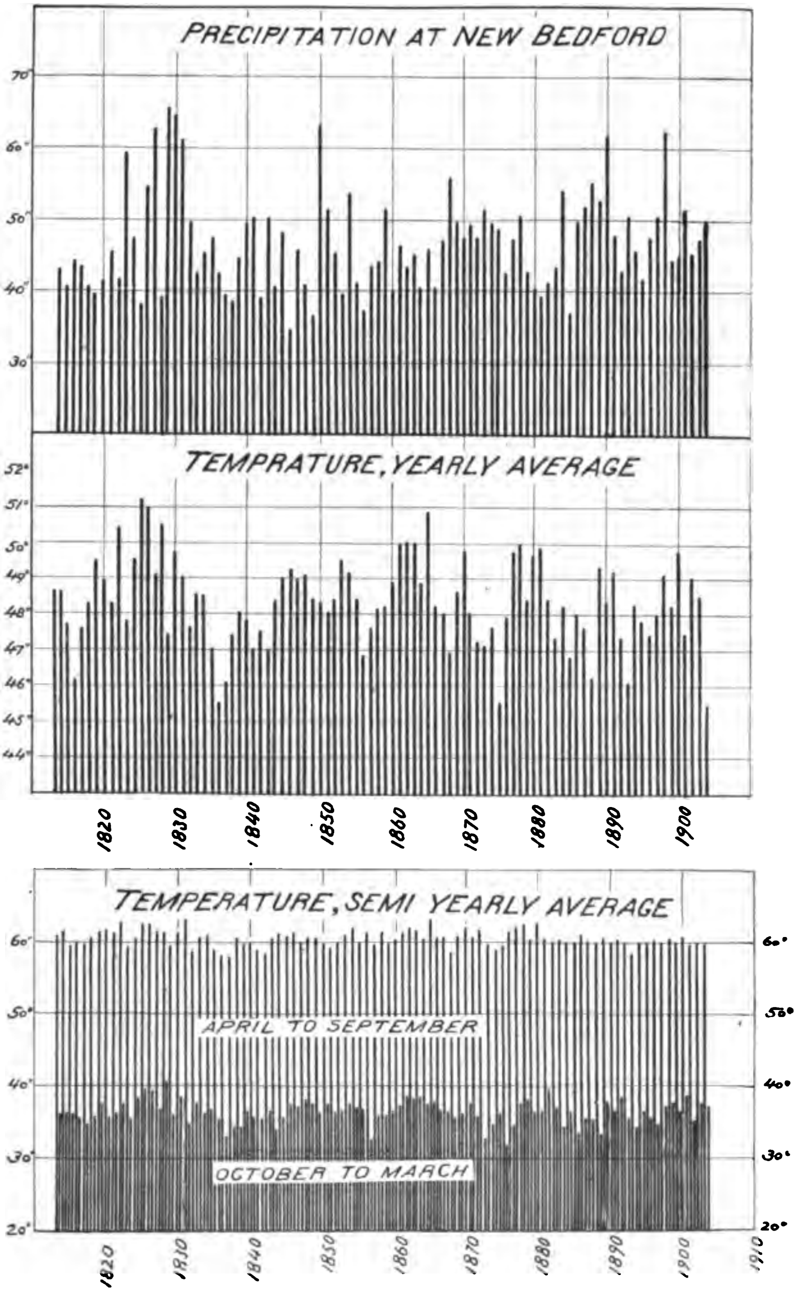

FIG. 1. — CLIMATIC CONDITIONS AT NEW BEDFORD.

temperature in short periods, yet as a whole the average temperature has not changed. The low winter temperature of 1836 should be noted; also that of 1844. It was on February 3, 1844, that the Cunard steamer *Britannia* had a channel cut through the ice of the harbor and was towed to sea with United States mails, etc. The ice extended nearly to Fort Warren. The winters of 1856 and 1875 were also notably severe.

With regard to precipitation, excepting a short period at about 1830 of abnormally large precipitation, there seems to be a tendency in this record to show an increase in the average annual amount, the average by ten-year periods being as follows:

1813 to 1820, 41.67 inches.
1821 to 1830, 51.95 inches.
1831 to 1840, 45.96 inches.
1841 to 1850, 44.94 inches.
1851 to 1860, 44.76 inches.
1861 to 1870, 46.26 inches.
1871 to 1880, 46.87 inches.
1881 to 1890, 48.69 inches.
1891 to 1900, 47.87 inches.
1901 to 1904, 48.69 inches.

Population is the basis of all vital statistics, so Fig. 2 shows the growth of population of Cambridge, Lowell, and Worcester.

Fig. 3 shows the curve of population growth for the state of Massachusetts, 1765–1900; note that in this state there have been three different rates of growth: From 1765 to 1830 the rate of increase was small, the curve running quite low, the yearly increase being only about 5 750. Rapid immigration and the development of manufactures in the next period, 1830 to 1885, brought the rate to 26 765 per year, a very marked increase; while from 1885 to 1900 the rate of increase has been 57 545 per year.

Fig. 4 shows the Cambridge birth-rate per 1 000 inhabitants. Attention should be given to the low rate indicated during the Civil War, 1861 to 1865, and also during the period of great financial depression, 1875 to 1879. The birth-rate from 1850 to 1859 was 37.83, while the rate from 1894 to 1903 was 29.54, a decrease of

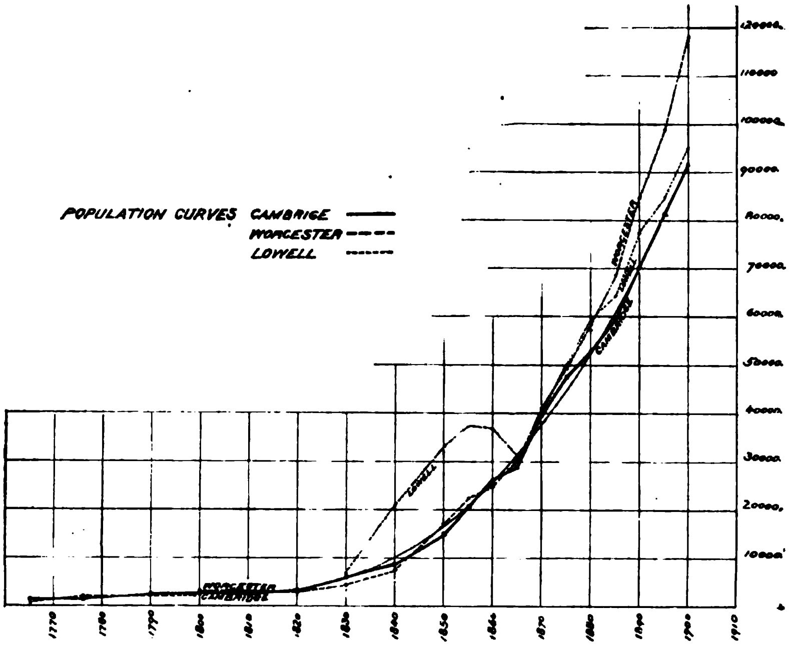
POPULATION CURVES CAMBRIGE
WORCESTER
LOWELL
WORCESTER
LOWELL
CAMBRIDGE
120000.
110000
100000.
90000.
80000.
70000.
60000.
50000.
40000.
30000.
20000.
10000.
0
1770
1780
1790
1800
1810
1820
1830
1840
1850
1860
1870
1880
1890
1900
1910

Fig. 2.

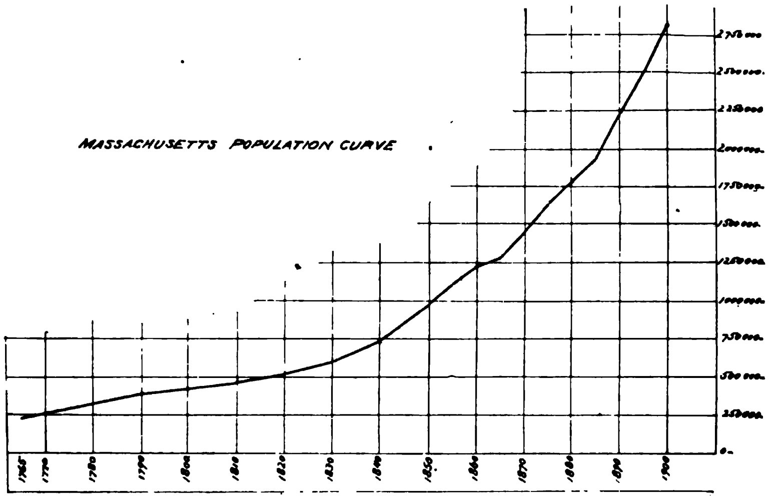
MASSACHUSETTS POPULATION CURVE
2750000
2500000.
2250000
2000000.
1750000.
1500000.
1250000.
1000000.
750000.
500000.
250000.
0.
1765
1770
1780
1790
1800
1810
1820
1830
1840
1850
1860
1870
1880
1890
1900

Fig. 3.

22 per cent. The decrease in the rate for the state of Massachusetts for the same ten-year periods was from 29.09 to 26.39, or over 9 per cent.

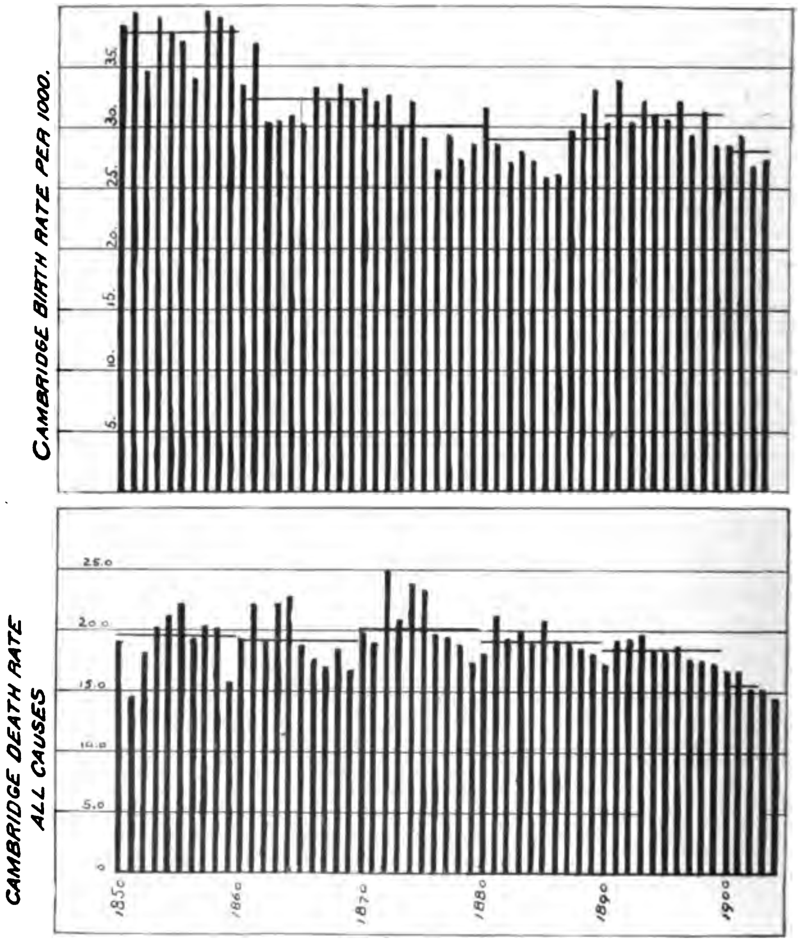

FIG. 4.

On Fig. 4 is also shown the Cambridge death-rate from all causes for the last fifty years. By ten-year periods the average rate is:

Period.	Death-Rate.
1850–1859	19.67
1860–1869	19.44
1870–1879	20.22
1880–1889	19.27
1890–1899	18.52
1895–1904	16.81

the last a reduction of 15 per cent. from that of the period from 1850 to 1859.

To get an approximate idea of what this decrease in the death-rate means, let us assume, as is sometimes done, that the average length of life is represented by the death-rate. Thus in the decade 1850–1859 a rate of 19.68 would represent an average duration of life of 50.3 years, and for the period 1895–1904 a rate of 16.81

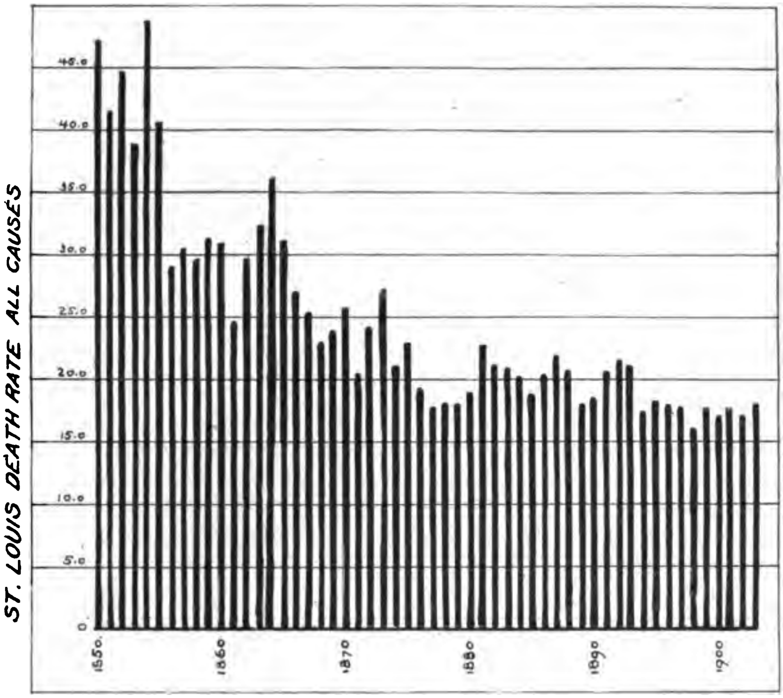

Fig. 5.

would represent an average life of 59.5 years, a gain of 9.2 years. Who can estimate the value of this lengthened life? Or, look at it another way. If the death-rate of the first period had been maintained till the present time, the total number of deaths in 1904 would have been 1 980. As a matter of fact, however, the total number of deaths was only 1 444, or 536 less than would have occurred if the early rate had continued, being just so many lives *saved*. If, now, we give to each life its legal valuation of $5 000, we have $2 680 000 as the total value of the lives saved for the year 1904 alone in the city of Cambridge.

This large decrease in death-rate seems to apply to most of the cities of the state, and considerably exceeds the decrease in death-rate for the state as a whole as given in the census reports. For the period 1850–1859 the rate was 18.25, and for 1894–1903 the rate was 17.80, a decrease of only 2.4 per cent. The death-rate for the cities seems to start higher and end lower than the rate for the whole state, probably due to the balancing influence of the rural districts where the first conditions would be likely to be better and less improvement would be expected.

Fig. 5 shows the death-rate from all causes for St. Louis, 1850 to 1904. This shows a remarkable reduction in the rate, from 43.08 per 1 000 for 1850 to 1859, to 71.71 per 1 000 for 1894–1903.

Compare (for what they are worth) the death-rates of several cities of nearly the same population as Cambridge. These rates are the average for the ten years 1894–1903.

City.	Population.	Death-Rate.
Lowell, Mass.	94 969	20.24
Albany, N. Y.	94 151	19.44
New Haven, Conn.	108 027	17.29
Worcester, Mass.	118 421	16.87
Cambridge, Mass.	91 886	16.81
Hartford, Conn.	79 850	16.24
Syracuse, N. Y.	108 374	13.48
Dayton, Ohio	85 333	13.35
Grand Rapids, Mich.	87 565	12.04
St. Louis, Mo.	575 238	17.71

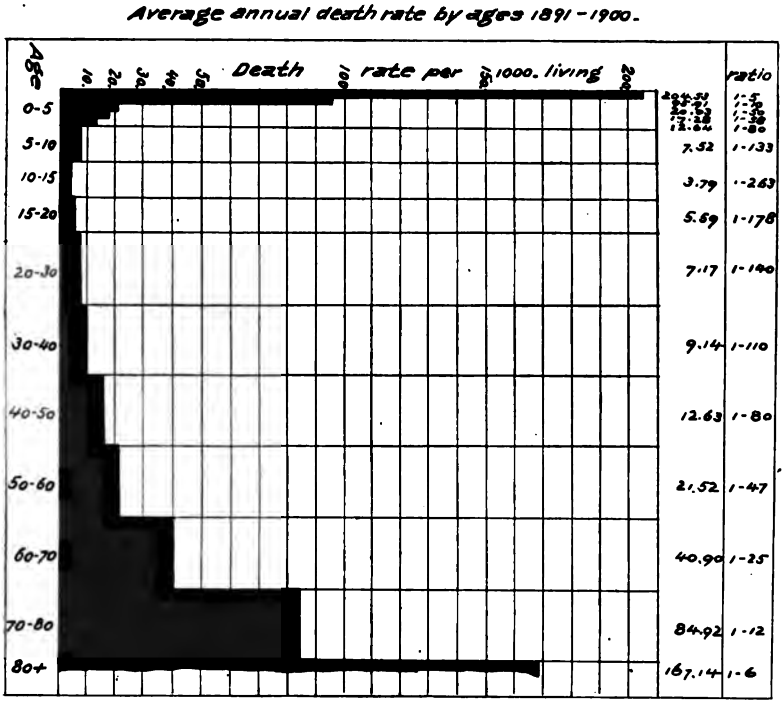
Average annual death rate by ages 1891-1900.
Age
Death rate per 1000. living
10.
20.
30.
40.
50.
100
150
200
ratio
0-5
5-10
10-15
15-20
20-30
30-40
40-50
50-60
60-70
70-80
80+
204.53
25.21
20.63
17.28
12.64
1-5
1-40
1-50
1-58
1-80
7.52
1-133
3.79
1-263
5.69
1-178
7.17
1-140
9.14
1-110
12.63
1-80
21.52
1-47
40.90
1-25
84.92
1-12
167.14
1-6

FIG. 6.

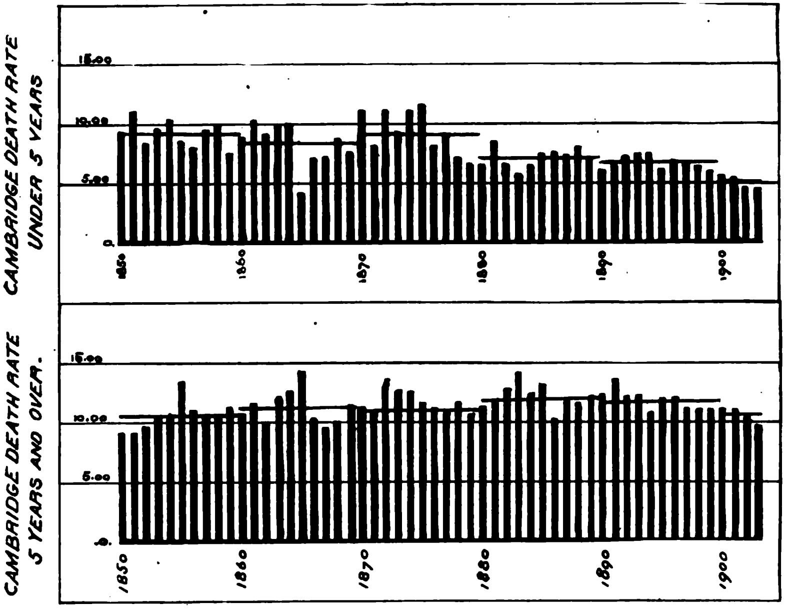
CAMBRIDGE DEATH RATE UNDER 5 YEARS
15.00
10.00
5.00
0.
1850
1860
1870
1880
1890
1900
CAMBRIDGE DEATH RATE 5 YEARS AND OVER.
15.00
10.00
5.00
0.
1850
1860
1870
1880
1890
1900

FIG. 7.

Fig. 6 shows the death-rate per 1 000 persons living of the given ages in Cambridge (1891 to 1900). The figures are as lows:

Age.	Death-Rate.	Mortality.
Under 1 year	204.53	1 in 5
1– 2	95.91	1 „ 10
2– 3	20.03	1 „ 50
3– 4	17.28	1 „ 50
4– 5	12.64	1 „ 80
5–10	7.52	1 „ 133
10–15	3.79	1 „ 263
15–20	5.59	1 „ 178
20–30	7.17	1 „ 140
30–40	9.14	1 „ 110
40–50	12.63	1 „ 80
50–60	21.52	1 „ 47
60–70	40.90	1 „ 25
70–80	84.92	1 „ 12
over 80	167.14	1 „ 6

Note the terrible mortality of children under one year of age, more than one in five dying.

On Fig. 7, however, it is shown that this mortality rate for children under five years of age is being reduced, the rate by ten-year periods being as follows:

Period.	Death-Rate of Children under Five.	Period.	Death-Rate of Children under Five.
1850–1859	9.26	1890–1899	6.77
1860–1869	8.33	1894–1903	6.08
1870–1879	9.25	1900–1903	5.10
1880–1889	7.25		

The last a decrease of 34 per cent. in child mortality from the period 1850–1859.

It should be remembered that these figures relate to the whole population of all ages, whereas children under five form about one tenth of the whole population, and these figures should, therefore, be multiplied by ten to obtain the rate for that age.

Fig. 7 also shows the death-rate in Cambridge for persons five years of age and over. The rates are successively 10.69, 11.28, 11.05, 11.92, 11.76; 1900–1903, 10.62; and 1894–1903, 11.04, showing little change in the death-rate for adult persons.

Fig. 8 shows the death-rate due to croup and diphtheria combined for both Cambridge and St. Louis. In Cambridge the rate in 1880–1889 was 1.316 and in 1894–1903 was 0.626, or a decrease of 52 per cent. St Louis shows a reduction from 1.152 to 0.435, or 62 per cent. This is undoubtedly largely due to the introduction of the antitoxin treatment. Professor Welsh states that in something like 5 000 cases of diphtheria, the history of which he examined, the use of the antitoxin treatment had reduced the mortality more than 50 per cent., while in Berlin the death-

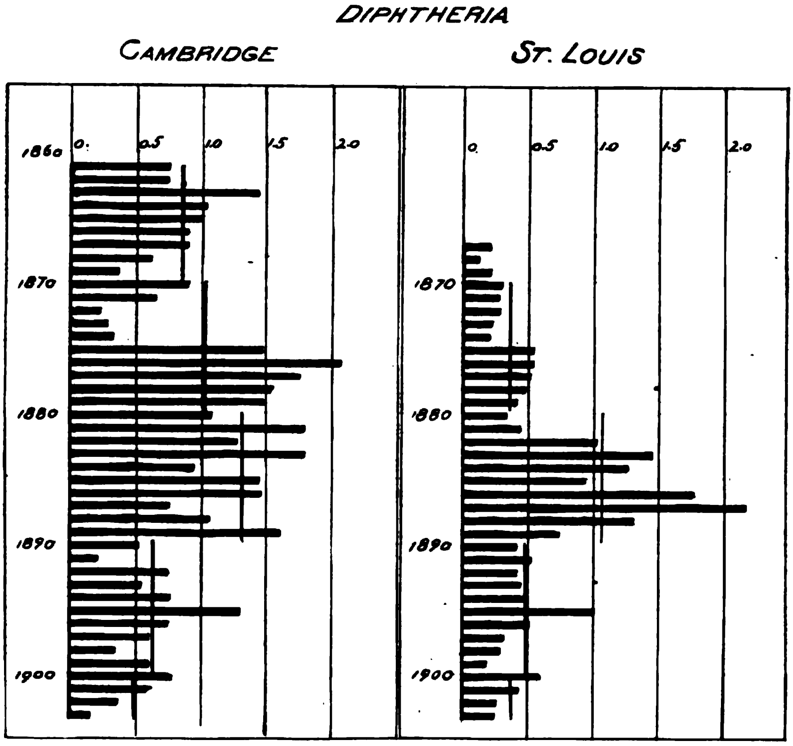

FIG. 8.

rate from this disease was reduced from 10.2 per cent. to 3.7 per cent., and in Paris from 6.5 per cent. to 1.3 per cent.

Fig. 9 shows the death-rate from typhoid fever for Cambridge and St. Louis. In Cambridge the maximum rate occurred in 1860–1869 at 0.456 per 1 000. The rate for 1894–1903 was 0.189, a reduction of 59 per cent. The St. Louis diagram is a very instructive one, as showing the influence of the sanitary condition of the water supply on the typhoid fever death-rate.

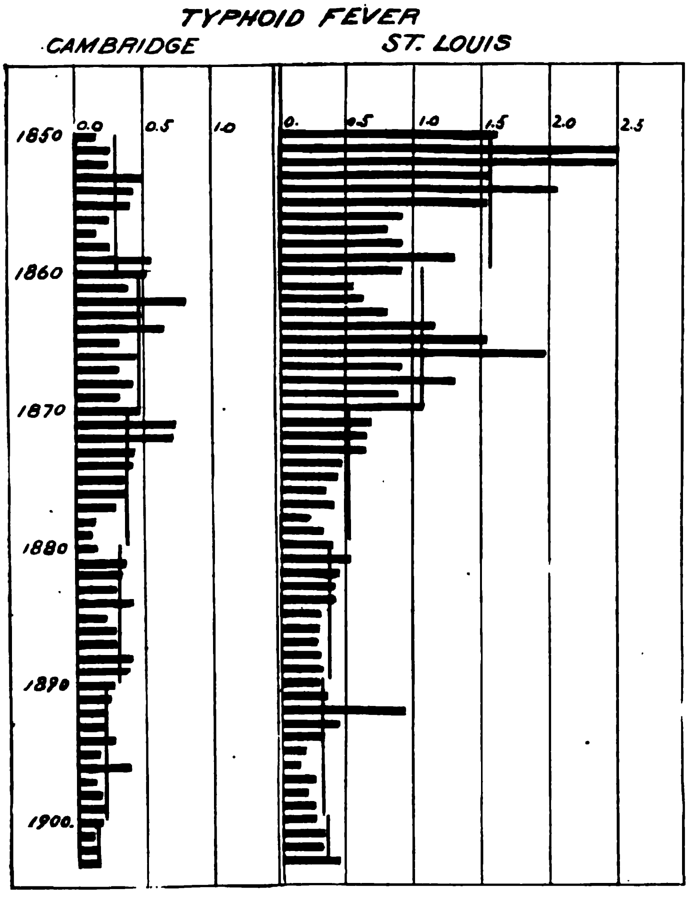

Fig. 9.

Mr. Moore, in his paper, states that the first water works for St. Louis were built in 1832, supplying a small amount of water from the Missouri River. Most of the inhabitants used water from wells until 1855, when the water works were enlarged and a more general use of river water was made, with a decrease in the typhoid death-rate until about 1863. About this time the construction of sewers discharging into two creeks connecting with the river above the pumping station was active and its effect is shown in an increase in the death-rate.

In May, 1871, the old water works were abandoned and moved up the river above the point when any sewage then entered the river. This produced another lowering of the rate until 1890, when it began to rise again. This was caused by the introduction of sewage into the river near the pumping station. In 1892 the city set some pumps on one of the creeks which was particularly dangerous, and pumped the water which was polluted over into a sewer which discharged below the pumping station. The rate again fell off so that in 1897 it was the lowest ever recorded in St. Louis.

The rise to the rate shown for 1900 is probably caused by the increasing amounts of sewage from the six cities on the river above St. Louis, and, it has been claimed, from Chicago itself and its great drainage canal.

Consumption causes, it is said, one seventh of all the deaths in the world. In Cambridge it causes about 12 per cent. of all deaths. There has apparently been improvement in the rate for this disease, although the figures must be taken with some caution, due to uncertainty as to the correctness of the returns of causes, many objecting to have the cause of death assigned as "consumption" as affecting insurance, and other interests. The average rates as given by the returns are as follows:

Period.	Death-Rate. from Consumption	Period.	Death-Rate. from Consumption.
1850–1859	3.901	1890–1900	2.336
1860–1869	3.116	1900–1903	1.962
1870–1879	2.930	1894–1903	2.046
1880–1889	2.948		

a gain of 47 per cent.

Not only does the disease cause a formidable portion of the deaths, but its victims are largely those in middle life, the period of largest death-rate being from twenty to forty years of age.

The returns of pneumonia are so unsatisfactory that no diagram

CONSUMPTION

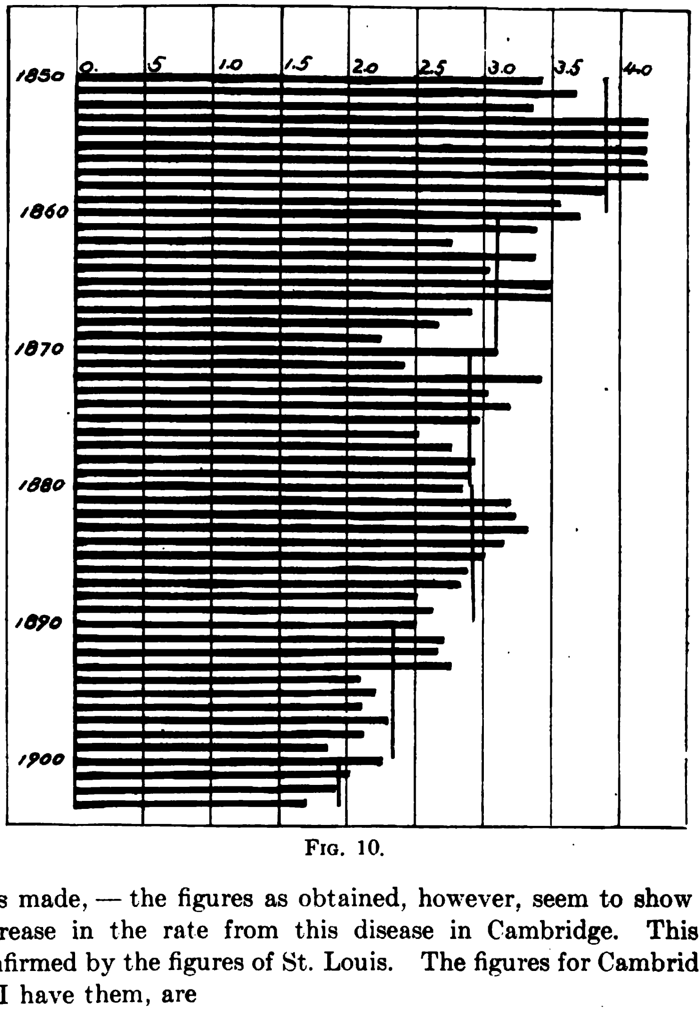

Fig. 10.

was made, — the figures as obtained, however, seem to show an increase in the rate from this disease in Cambridge. This is confirmed by the figures of St. Louis. The figures for Cambridge, as I have them, are

Period.	Death-Rate from Pneumonia.	Period.	Death-Rate from Pneumonia.
1872–1879	1.33	1890–1899	1.60
1880–1889	1.69	1900–1903	1.760

We have now seen, from the figures and diagrams presented, something of the results which have been accomplished in the last fifty years in the effort to solve the great problem of the conservation of human life.

It seems certain that in this period the danger of recurrence of great epidemics has been greatly lessened, that the mortality from many contagious diseases has been greatly reduced, and that on the whole the average length of human life has been increased. As to how far this improvement may be carried in the future, it does not seem too much to expect that, with our constantly increasing knowledge, and attention to the details of sanitary conditions and hygienic living, the improvement will continue, and that at no distant date we may have a death-rate considerably lower than the present one. We can never hope to banish *entirely* disease and death, even if it were desirable, yet there are many lines along which improvement can be made in things pertaining to public health, and by which not only may the *length of life* be increased, but its *vigor*, *activity*, and *capacity for useful work* augmented.

It does not seem, for instance, that *consumption* can for long continue the great scourge that it now is to the human race, cutting down so many in middle life, but that with all the study and investigation now being given to the pathology of this disease, it is not unlikely that some definite and efficient treatment will be found, by which the " bacillus tubercle " will be overcome and mankind will be comparatively free from this disease.

It is probable that at no distant day most, if not all, the water furnished by public water supplies will be thoroughly purified by some form of filtration, either mechanical or through layers of sand, as is now being done at Albany, Pittsburg, Philadelphia, and many foreign cities, giving a water practically free from the

" bacillus coli " and other bacteria, and thus help to materially lower the *typhoid fever* death-rate.

It may be that even the *air supply* of all buildings where people live or are employed will be purified and cleansed, and the gas. dirt, smoke, and floating germs literally washed out, as is now done at the city hall in St. Louis, Mo., reducing the liability to throat and lung diseases.

The immediate removal of *sewage* and *garbage*, and its disposal without offense and without danger, is another serious problem which should find some satisfactory solution. It may be, too. in that future time of which I speak, that *free public baths* will be furnished by all municipalities, open the year round, and that daily bathing in these, or in a private bath, will be made compulsory, the same as attendance at the public schools or vaccination now are.

Think what this would mean, from a sanitary standpoint, to the " great unwashed," to say nothing of how much it would contribute to the esthetic olefactory senses of the patrons of many of our street car lines at certain hours of the day!

It may be, too, and this seems the hardest of anything to believe or expect, that we shall some time learn to eat and drink only so much as we need, and then only of such things as are good for us. When that time comes, it may be expected that the public health will be so good that the practice of medicine will be a lost art, and these figures and mortality tables will have to be completely revised and corrected.

DISCUSSION.

PRESIDENT SEDGWICK. It has been said that the one incurable disease is old age, but when you look at the statistics you will find that only a small proportion of deaths is given as from that cause. People seem to die of everything except old age, only about 4 or 5 per cent. being put down to that. But such a percentage is apparent rather than real. A good many people die of pneumonia, for instance, who really die of old age — that is, who would not have died of pneumonia if they had not been enfeebled by age.

There are many aspects of this subject which will bear serious thought. The chart of mortality at different ages is particularly valuable and interesting. I have one very much like it, a lantern slide, for Berlin, Germany. It is higher in the infant mortality than the one shown by Mr. Hastings. One of the striking things which appears from the study of that subject is that infants fed on cow's milk — bottle-fed infants — die at a much higher rate than those that are breast fed. There is an infinite amount of work which can be put into all these diagrams and studies.

It seems to me it is well to have such things brought before us now and then, just to remind us of the actual facts of life and of the tendencies of the times. In these tendencies this association has played an important part in Massachusetts by seeing to it that the water supplies are made purer and better; thereby reducing not only typhoid fever but some other diseases, because there is a good deal of evidence now-a-days that a number of diseases are water borne, which we did not formerly consider water borne, — not, of course, borne with the same readiness and to the same extent as typhoid fever, but still sufficiently to cause a good deal of trouble.

Mr. Frank L. Fuller. I think we owe a great deal to Mr. Hastings for the labor he has put into this paper. The results of his work are very instructive indeed and will be very valuable and interesting for purposes of future reference and comparison. I should like to ask Mr. Hastings whether he has made an enumeration of deaths from accidental causes.

Mr. Hastings. No, sir; I didn't go into that.

Mr. H. A. Miller. I understand that the death-rate among infants was much greater formerly than in later years, and at the same time the birth-rate has decreased. If the birth-rate had remained as it was, would the death-rate have remained the same, or would it have been greater or less?

Mr. Hastings. The death-rate I gave for infants was for the infants living, so it wouldn't make any difference how many there were, the rate would be the same. The diagram I showed you gave the death-rate of children under one year, living at that age, and the death-rate of children under two years, living at that age, so the number would not have any effect.

Mr. Miller. I probably did not make myself understood. The death-rate among infants, as I understand it, is smaller than it used to be, while the birth-rate also has decreased. That is, you gave us the total death-rate of all ages, as I remember, and that has decreased?

MR. HASTINGS. Yes, sir.

MR. MILLER. Now, if the birth-rate had remained normal, or remained the same as it originally was, would the death-rate total be in proportion, or would it have decreased as shown by you? Do you get an idea of what I mean?

MR. HASTINGS. I think so. I think if there had been more children the death-rate of all ages would have been higher, because the mortality among children is larger.

MR. MILLER. Would it have been the same practically as it was originally?

MR. HASTINGS. I couldn't say as to that, but I don't think so.

THE PRESIDENT. Perhaps I may say a word about that, as I happen to be more or less familiar with the subject. A high birth-rate is generally supposed to favor a high death-rate, and yet, if the birth-rate had remained as it used to be, it is not likely that the infant death-rate would have been as high as it then was; although it would have been higher than it now is.

MR. DESMOND FITZGERALD. I will say a single word in regard to the population curve shown on the diagram. Some time ago I had occasion to examine very carefully the increase in population of all the principal cities of the United States for the city of Oakland, Cal., on a subject connected with their sanitary works, and I found that of all the cities in the United States the city of Worcester had increased from the beginning of its records to the present time in the most regular way, showing an almost perfect curve. The city of Providence, I think, came next, and was very similar.

MR. ROBERT J. THOMAS. I should like to ask whether in taking the population of Cambridge the students in Harvard College were included?

MR. HASTINGS. I think so. They are enrolled as living in Cambridge, although very few are voters there. There has been quite a discussion about that, whether students who are enrolled as inhabitants of Cambridge really have a domicile or residence there. They are included as inhabitants, but, generally, not as voters.

MR. THOMAS. They come into the population statistics?

MR. HASTINGS. Yes; and that would explain somewhat the rate of our increase in population. We have about 5 000 students, and they are not expected to contribute much to the birth-rate.

THE PRESIDENT. Mr. Mills has drawn a very interesting curve for Lawrence, by which he has shown that the introduction of the filter in 1893 was followed by a very marked increase of population and decrease of the total deaths. It is one of the most instructive curves I have ever seen. I do not remember the exact figures, but the gist of it is that, assuming the total number of deaths in Lawrence in 1892 as 1 000, and it was going rapidly up by a line which would diagonalize that chart, when the filter was introduced the line changed its direction altogether, so that after ten years the total number of deaths in the city was no greater than it had been in 1892, and that, too, although the population had increased meantime 50 per cent. It is a very extraordinary showing as to the effect of a purified water supply upon the public health.

MR. MORRIS KNOWLES.* There is something which occurs to me, which may be of interest in teaching us not to draw conclusions too quickly, unless we know all the facts. An instance which occurred in our city of Pittsburg during the last year illustrates this. As you all know, it is the city which leads all others in death-rate and sickness from typhoid fever. For some years past the average reported cases of sickness per 100 000 has been 750 to 800, and the cases are generally recorded. During the past year, through the energetic efforts of the head of the bureau of health, it has been made manifest to every one that it is not wise to drink water from the municipal supply. Notices have been posted in the street cars and in the public buildings, office buildings and other places, that the city water should be boiled before it is used for drinking. In buildings where good water is furnished, that fact is placarded, so that people will know that the water is safe.

Now it is not probable that there has really been a twofold increase in the number of typhoid cases within the past few years. There has probably been some increase, but I doubt if the increase has been anything like what it appears from the statistics to have been this year. The statistics so far show that there have been about twice as many cases of typhoid fever in the city as ever before. In other words, instead of being 750 or 800, there will probably be reported 1 400 per 100 000, while the deaths will remain about the same as heretofore; that is, the death-rate this year will be about 10 per cent. instead of 15 to 18 per cent. The probable explanation is that it is popular now to report diseases as typhoid which are doubtful; and formerly not all were reported which should have been, and it shows that it is not always safe to trust statistics unless one knows the facts.

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* Chief of the Bureau of Filtration, Pittsburg, Pa.

THE PRESIDENT. That applies to cases rather than to deaths, because deaths are much more accurately reported.

MR. CHARLES R. FELTON.* It is astonishing how closely you may predict from a population curve what the future population of a city will be, at least we have found it so in Brockton. We have had a curve plotted for several years, and have come remarkably close in our predictions on the last three censuses. Just prior to our last census the reporters, in attempting to forecast what it would show, interviewed me, and I simply referred to the chart and predicted a population of 48 000. After the first returns came in the reporters joked me a little on having missed it because I was 18 off. I said there must be some mistake, and our later returns gave us within 6 of my figure.

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* City Engineer, Brockton, Mass.

ON THE PROTECTION OF PUBLIC WATER SUPPLIES FROM POLLUTION DURING THE CONSTRUCTION, MAINTENANCE, AND OPERATION OF RAILROADS, WITH SPECIAL REFERENCE TO THE WATER SUPPLY OF SEATTLE, WASHINGTON; TOGETHER WITH CRITICISMS OF THE PRESENT METHODS OF WATER SUPPLY AND SEWERAGE OF RAILWAY TRAINS.

BY WILLIAM T. SEDGWICK, PROFESSOR IN THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON, MASS.

[*Read September 14, 1906.*]

In an address before the New England Railroad Club, in Boston, in November, 1899, the author drew the attention of railway managers to the unsanitary and objectionable practice of allowing the droppings of the closets of passenger cars to be scattered all along the lines, polluting the trucks and roadbed, and to a greater or less extent the air, the soil, or water in the vicinity. Since that time other writers have touched on the same subject, but for one reason or another it has as yet received but little attention.

Railways, both steam and electric, in rapidly increasing numbers, have been constructed, maintained, and operated upon the collecting grounds, alongside the principal tributaries, and even over portions of the storage reservoirs, of numerous water supplies, without exciting more than occasional comment or protest. Suddenly and unexpectedly within the last few months the whole subject has been brought to the front by the proposed construction of a great transcontinental railway close alongside a mountain stream used without filtration or storage as the water supply of a large and rapidly growing American city, namely, the city of Seattle, Washington. The Chicago, Milwaukee & St. Paul Railway, in seeking entrance to Seattle, after having selected the Snoqualmie Pass as the proper place for crossing the lofty Cascade Mountains, found the best route from the pass to that city to be one which for 11 miles runs through the valley and very near the shores of

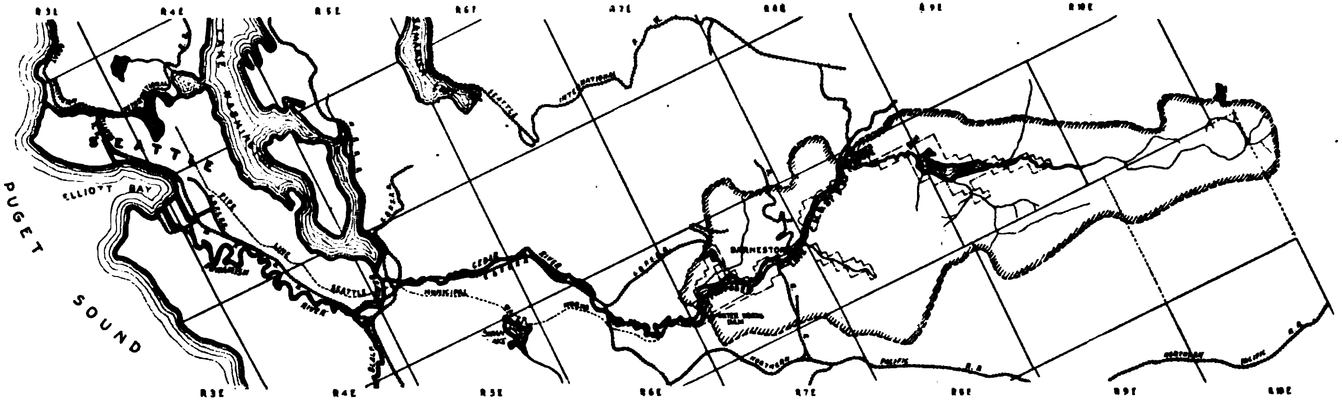

FIG. 1.—MAP SHOWING PROPOSED ROUTE OF CHICAGO, MILWAUKEE & ST. PAUL RAILWAY, THROUGH CEDAR RIVER WATERSHED. (SCALE ABOUT 8 MILES TO AN INCH.)

Cedar River, the source of the public water supply of Seattle, as shown on the map, Fig. 1. Much of the land bordering Cedar River is owned by the city of Seattle, having been purchased under the advice of its able and intelligent city engineer, Mr. R. H. Thomson, for the express purpose of protecting the watershed. Hence it became necessary for the railroad to obtain from the city a right of way over this land. This was arranged to be done by means of an ordinance requiring the mayor to sign deeds for such a right of way 100 feet wide and 11 miles long through the watershed and for most of the way very near the river. Such an ordinance was accordingly drawn up, passed by the city council on May 21, and approved by the mayor on June 5 of the present year (1906).

This ordinance marks the beginning of a new epoch in the relation of railways to public water supplies, and hence deserves thorough and careful consideration. As far as I am aware, it is the first example on record of the frank recognition of the dangers involved in the construction, maintenance, and operation of a railway along the shores of a public water supply, together with explicit and extensive provisions for meeting them. I make no apology, therefore, for quoting from it at length. It is entitled:

"ORDINANCE NO. 13 836.

"An ordinance granting to the Chicago, Milwaukee & St. Paul Railway Company of Washington, its successors and assigns, a right of way one hundred (100) feet in width for the location, construction, maintenance, and operation of a railroad across and through lands owned by the city of Seattle, in the county of King, state of Washington, and authorizing the execution and delivery of a conveyance of such right of way. Be it ordained by the city of Seattle as follows:

"SECTION 1. That there be, and hereby is, granted to the Chicago, Milwaukee & St. Paul Railway Company of Washington, its successors and assigns, a right of way, in perpetuity, for the location, construction, maintenance, and operation of a railroad upon, across, and through the lands owned by the city of Seattle, in the county of King, state of Washington, one hundred (100) feet in width, being fifty (50) feet of such width on each side of the center line of the railroad of said company as located and staked out upon the ground, which lands are described as follows, to wit: . . .

" Provided, however, that nothing in this ordinance contained shall be construed to grant any right to said railway company, its successors or assigns, to occupy or use the bed of the stream of Cedar River, or any portion thereof, or any of its tributaries, except so far as herein authorized for the purpose of constructing and maintaining bridges across said river or for the purpose of constructing and maintaining embankments for the roadbed of said railroad.

" SECT. 2. The grant of the right of way herein contained is upon and subject to the following conditions, to wit:

" 1. Said grantee shall begin the construction of its railroad upon the right of way herein granted within one (1) year. . . .

" 2. No station shall be established or maintained by said railway company, its successors or assigns, between the city intake and the easterly terminus of the right of way herein granted without the consent of the city of Seattle first having been granted by ordinance.

" 3. While the said right of way is being cleared and prepared, and during the construction of said railroad thereon, the camps or living quarters of the men engaged in such work, and the accommodations for any animals employed thereon, shall be located and maintained at such distance from said Cedar River, in good sanitary condition, as shall be approved by said city of Seattle.

" 4. The grantee, its successors and assigns, shall locate the living quarters of any and all employees engaged in the care and maintenance of the railroad constructed upon the right of way herein granted, or in the operation and maintenance of any side or passing tracks, water tanks, telegraph or block signal stations or towers, or other appliances, constructed and maintained upon said right of way, at such distance from Cedar River as shall be approved by the city of Seattle, and shall maintain such living quarters in good sanitary condition.

" 5. The said city of Seattle may employ an inspector to patrol or inspect the work of construction of the said railroad upon said right of way for the purpose of ascertaining whether said work is being prosecuted in accordance with the conditions herein contained, and said grantee agrees to pay the cost of such inspection."

Then follows a location of the bridges to be built, with a provision at the end as follows:

" All bridges constructed upon said right of way across any creeks or streams intersecting said right of way shall be solid-decked structures, and all bridges, trestles, and approaches shall be constructed and maintained so as to prevent any foreign matter from dropping from engines, cars, or trains passing over the same into Cedar River or into the creek or streams running into said river.

"7. Said grantee, its successors and assigns, shall not, during the construction of said railroad, or thereafter in the maintenance or operation thereof, place, throw or deposit, or permit the placing, throwing, or depositing in said Cedar River, or in any creeks or streams running into said river, or upon any ground adjacent to said river, any offensive or deleterious matter which may cause the pollution of the waters of said streams, and said grantee, its successors and assigns, shall at all times maintain the right of way herein granted, and the railroad constructed thereon, in such manner as not to cause any pollution to said stream."

Further on is a section in which it is provided that if the railroad, in order to avoid curves of more than 3 degrees, finds it necessary to go into the river,—

"Embankments required for the proper support of said roadbed may be extended into the bed of the stream, provided that such embankments shall be built of such material and in such manner as to avoid pollution of the waters of said river, and so as to prevent the escape or passage of offensive matter from or over said embankments into the said river."

Finally, there is a section not only authorizing the mayor and comptroller, but directing them, "upon the taking effect of this ordinance, to execute and deliver to said grantee a deed conveying in perpetuity . . . the right of way herein granted . . . for the construction, maintenance, and operation of said railroad. . . ."

The ordinance was passed by the city council on May 21, 1906, and approved by the mayor on June 5. It thereupon became incumbent upon the mayor to issue the deeds by which the railroad should acquire the right of way, and it was supposed that such deeds would issue without delay. Up to this time there had been no open opposition to the plan, the ordinance having been prepared by the legal representatives of the railroad company and the city officials, acting together. I am assured by the railroad officials that it was their intention to protect the water supply in every possible way, and that they believed they had fully and adequately done so by the provisions contained in the ordinance.

Not long after the mayor had signed the ordinance, but before he had signed any of the deeds contemplated under it, an agitation arose in the city, alleging that the water supply, instead of being safeguarded by the ordinance, was in reality seriously endangered by it, inasmuch as the building of the railway must of necessity bring into the valley hundreds of laborers of an uncleanly type, who would inevitably pollute the river, while its maintenance and operation necessarily involved the temporary or permanent presence in the watershed of section hands, signal men, trainmen, wrecking gangs, and others, not to mention the thousands of passengers who would annually travel on the road and use the car closets, spit from the car windows, or otherwise contaminate the watershed.

This agitation rapidly grew to large proportions, being participated in by physicians, labor organizations, women's clubs, the Chamber of Commerce, good government clubs, and other public bodies, and before long culminated in an order issued by court on application of the King County Medical Society, composed of physicians in Seattle and vicinity, restraining the mayor from signing the deeds. I am informed that the legal representatives of the railroad, who supposed that they had amply and even generously provided for the protection of the water supply, were nonplussed at this sudden outbreak of popular feeling, and unable to understand why it had arisen, or why it should have reached such proportions. Of the reality or extent of the objections there was, however, no doubt, and in self-defense against the popular storm the authorities of the railroad secured the services of several experts to investigate the subject and report to them upon the question whether the railroad could or could not be built, maintained, and operated in Cedar Valley, as proposed under the ordinance, without endangering the purity of the public water supply of Seattle. These included Mr. J. W. Alvord civil engineer, a member of this Association; Professor Pammel, of the Iowa State University; Professor Bissell, of the Mechanical Engineering Department of the same institution; Prof. E. G. Smith, of Beloit College, and afterward the writer. Mr. Alvord, Professor Pammel, and Professor Bissell in due time made their reports, and a brief summary of Mr. Alvord's report appeared in the *Engineering News*, page 238, August 30, 1906; the complete report follows as an appendix (A), page 442, to this paper. These reports threw much light on the situation but did not appear to the citizens to settle the question, and hence did not calm the popular storm.

The citizens of Seattle had long supposed that in Cedar River they possessed a perfect water supply, for Cedar River is a beautiful stream, running through a virtually uninhabited district, and forming the outlet of Cedar Lake, a large sheet of water lying, remote and almost inaccessible, 1 500 feet above the city in the Cascade Mountains. It is surrounded by mountains rising several thousand feet about it, — a lake probably as beautiful as is Lake George. When, therefore, Mr. Alvord showed that there were a number of logging camps on the watershed with very defective sanitary appliances, practically draining directly into the stream or its tributaries; when he further showed that the sawmill camp of Barneston, having about one hundred and twenty people, partly Asiatics, connected with it, was virtually draining into the stream, and that similar nuisances existed elsewhere on the watershed, the people of Seattle were surprised and greatly annoyed. The conclusion of Messrs. Alvord, Pammel, and Bissell, briefly stated, was that the water supply was already far from perfect, that the railroad could be safely built through the valley, and that it would not be as much endangered by the coming of the railroad as it was already endangered by existing nuisances.

Professor Smith arrived on the ground somewhat later than Mr. Alvord, Professor Pammel, and Professor Bissell, and proceeded to make his own investigations. The author arrived later still, but even before he had come the physicians and other objectors to the ordinance had expressed their readiness to accept as final the opinion of any one whom they considered as an unprejudiced expert, or of any group of such experts, regarding the question at issue. After considerable discussion and delay it was agreed on all sides to leave the settlement of the matter to a commission consisting of Dr. A. C. Abbott, Professor of Hygiene in the University of Pennsylvania and health officer of the city of Philadelphia, on behalf of the city of Seattle; Dr. Charles Harrington, Professor of Hygiene in Harvard University, and secretary of the State

Board of Health of Massachusetts, on behalf of the King County Medical Society; and the writer, on behalf of the railway company. Meantime, Mr. John R. Freeman, the eminent hydraulic and sanitary engineer, who fortunately happened to be passing through Seattle on his way to Alaska, was prevailed upon to visit the watershed with some of the other experts and to make a special report on the subject to the State Board of Health of Washington which, through its energetic and able secretary, Dr. E. C. Heg, had already taken an active interest in the problem and had instructed its engineer, Prof. W. J. Roberts, of Pullman, Wash., to make an independent investigation.

As a matter of record and for convenience of reference, the report of the commissioners, Mr. Alvord's report, and Mr. Freeman's report are printed as appendixes to this paper, and since these cover completely and in detail all the points at issue I need not here dwell further upon these. There still remain, however, certain other important aspects of the relation of railroads to water supplies which deserve our careful consideration.

THE WATER SUPPLY AND SEWERAGE OF RAILWAY TRAINS.

As I have already said, as long ago as 1899 I urged the members of the New England Railroad Club to devise some better methods of disposing of excrements than those now customary on railroad trains. I dwelt also at much length upon the need of improved water-supply arrangements — a subject which still deserves the closest attention. Through cars are often run great distances, passing through various cities and towns en route, and receiving from time to time fresh supplies of water. It may, therefore, easily happen that if any one of these supplies is impure, the water tanks shall become contaminated, and persons traveling in the car, or even joining it at stations which have excellent water supplies, may be exposed to the danger of contracting disease. I have myself had offered to me in a dining car in New England a clayey water which had obviously been taken into the water tanks on the previous day when the water supply of the car had been replenished in Washington, D. C. To a very much less extent travelers may be exposed to similar dangers from contaminated ice.

The importance of the distribution of contaminated water from large centers such as Chicago, Cleveland, Pittsburg, and Washington, having now or having recently had polluted water supplies, is very great, and well deserves the keenest attention of epidemiologists, especially of those who have been puzzled to explain the excess of typhoid fever in the United States over that in other civilized countries, such as England and Germany. At the same time the railroad companies can hardly be blamed for filling their water tanks from any accessible water supplies which are locally deemed good enough for the use of the public.

There still remains, moreover, a feature of the method used for water supply within the cars themselves which calls for serious criticism, and that is the use of the common drinking cup which here, as always, is a well-known sanitary abomination. A dozen or more years ago it was the almost universal custom on American railways for one of the brakemen to carry through the cars a tin can to which were attached a couple of removable cups or glasses. These were used in turn by thirsty passengers who remained in their seats, the glasses being filled for them by the brakeman as he paused for the purpose. This practice is now largely done away, and in its place a single cup or glass is kept under a fixed water tank, from which a jet of water can readily be drawn into the cup or tumbler, which is thus intended to serve the wants of the population of an entire car. Any one who thinks that this plan of meeting the water-supply needs of a large number of people of all sorts is either attractive or wholesome, has only to sit near the water tank of a crowded excursion train on some hot summer day, especially if the car is filled with mothers and young children, in order to be quickly convinced that a reform is here urgently demanded. Few things are more trying to a sanitarian than to observe a series of thirsty passengers of all degrees of cleanness and uncleanness applying their lips in succession to one and the same tumbler which is seldom, if ever, even rinsed between times. Wholly apart from the question of the quality of the water furnished, the opportunity here provided for the exchange of disease germs must be apparent to any one, and I need not further enlarge upon this custom, which is both familiar and disgusting.

A remedy might easily be found by having the faucet of the water tank bent upward and provided with a special orifice so that a small jet should rise for an inch or so above its tip, thereby furnishing a " sanitary fountain " similar to those which, in increasing numbers, are being provided in parks, playgrounds, gymnasia, schools, and other places where many persons must, of necessity, drink from a common supply. Travelers should also be encouraged to bring with them on railways their own private drinking cups.

Criticisms have frequently been made of the filling of the water tanks and the handling of broken pieces of ice for the tanks by employees whose hands are far from clean, and it must be admitted that the whole matter of the water supply and ice supply of passenger trains frequently leaves much to be desired in the way of sanitary improvement.

As for the sewerage of trains, within a few years, and from motives of mere decency, the custom has become general of locking the closets for the purpose of excluding passengers from them on trains approaching or standing at important stations, a practice which, as will be explained beyond, while certainly contributing to the cleanness of the station platforms, is decidedly objectionable on hygienic grounds. Only in very rare cases, however, so far as I am aware, are the closets of the numerous passenger trains on a great trunk line kept locked for several miles while approaching and after leaving a station, not for decency's sake but in order to protect a public water supply.

Near the city of New Haven, Conn., many travelers have noticed that the closets on the Pullman and other cars going east are kept locked after leaving that city until Branford, nine miles away, has been passed. Going west, the closets are locked as the trains approach Branford and are not unlocked until after leaving the New Haven station. I am informed that the reason for this practice is that some two or three years ago inspectors employed by the New Haven Water Company, while patrolling the Lake Saltonstall watershed near Branford, observed and reported upon the presence of fecal matter on the rails or roadbed, very near the intake of the Lake Saltonstall supply of the water company, which company thereupon complained to the railway officials, who issued an order requiring all closets to be kept locked on trains traveling between Branford and New Haven. I am also informed that a similar rule requires the locking of all closets on trains on the Northampton Division of the same road between New Haven and Cheshire, a distance of fifteen and one-half miles, for the better protection of another supply of the New Haven Water Company, the Lake Whitney supply.

I have been unable, however, to find that any similar precautions are taken in regard to freight trainmen. On the contrary, inquiries have shown that on our eastern railroads the freight brakemen and trainmen have to get along the best way they can in answering the calls of nature. I am told that in the West there is generally a closet in the caboose for the use of these men, but that near Boston the crews of freight trains either make use of empty box cars, which they defile at their convenience or necessity, or of the coal pile in the tender; or that, when taken hurriedly, they even use as a seat the couplings or bars connecting the cars — obviously an uncomfortable and dangerous practice, especially when the train is moving rapidly. All of these facts further illustrate the crudity and primitive character of the sanitary arrangements of our American railway trains, for, obviously, no occasional locking of closets on passenger trains will ever be more than a partial and very superficial remedy of the present crying evils.

The New Haven case is the only one of which I have heard in which definite fecal pollution of the rails was observed near a water supply, or in which any similar observation led to an immediate attempt at reform. I have recently learned, however, from Mr. R. W. Pratt, chief engineer of the State Board of Health of Ohio, of a case, not exactly identical with the New Haven case, but so nearly in the same category that I have asked him to give me a statement of it, which he has kindly done, and which he permits me to quote here:

> "The village of Plymouth, Ohio, has, until recently, used as a partial source of water supply a small tributary of the Huron River. Water was taken at a point a short distance southeast of the village, immediately north of, and very near, the Northern Ohio Railroad bridge, which spans this tributary stream or creek. Two hundred feet west of the creek, and twenty or thirty feet above it, adjacent to the railroad, is a water tank used for railroad pur-

poses. A small gully runs from the tank to the stream, which it enters just above the intake.

"In June, 1905, during an inspection of the public water supply by a representative of the Ohio State Board of Health, an eastbound train, composed of freight cars, cattle cars, and one passenger coach, stopped at the tank to take water. After filling the locomotive tender, the train slowly passed on to such a point that the forward cattle car was brought directly opposite the tank. The day being hot, the animals were badly in need of water. In order to water them, a brakeman swung the spout of the water tank directly into the car, turned on the water and signaled for the locomotive to move slowly forward. By this procedure the cattle and hogs in the several cars were given a generous shower bath, while much of the accumulated filth in the bottom of the cars was flushed out into the gully by the side of the track, through which it flowed rapidly down to the creek, quickly entering the latter at a point not more than fifty feet above the intake of the Plymouth water supply.

"Inquiry showed that this was a common practice on the part of the railroad men during warm weather. It should be added, however, that the railroad officials, when the matter was brought to their attention, agreed to see that the practice was discontinued; and that the village has recently taken steps to procure a sufficient water supply from other sources, so that the use of the creek water will not be necessary in the future."

This case seems to me to be a very important contribution to the literature on this subject, which at best is but scanty, for I may say parenthetically that I have examined English and German authorities and have found nothing of any consequence in them on this subject. One would, perhaps, not expect to find much in such works, because foreigners, as a rule, use closets at stations, leaving the trains when necessary for that purpose. It is, generally speaking, only on the fastest trains that closets are provided, and from a German work on railway hygiene, published in 1904, it appears that the discharge pipes from the closets of German express trains discharge their droppings upon the roadbed precisely as ours do.

Finally, quite apart from the matter of sewage disposal, let us consider briefly the hygienic aspect of locked closets on railways. In the first place, although it is true that our commission recommended the locking of the closets while trains were going through the Seattle watershed, we did not depend upon such locking as an entire safeguard, and I do not believe that locking ever will be a complete safeguard. There are times when people are ill, when they simply *must* get access to the closets. There are times when persons so imperatively require to get into the closets that they will tip the porter heavily, or do almost anything, in order to obtain admittance. And they ought to obtain entrance. It is a hardship, and worse, not to allow access to the closets, the locking of which must be pronounced, once and for all, an imperfect, crude, and, not infrequently, an absolutely barbarous device. The practice is rude and unhygienic, even in its least objectionable form of locking the closets only while the train halts at stations. For any longer period, as for example, while trains are covering the distance from New Haven to Cheshire or New Haven to Branford or *vice versa,* it is much worse.

Moreover, the practice is not only barbarous and unhygienic, it is often ineffective. How is anybody going to be driven out of a closet at the right time if he is already in it before the train arrives at New Haven going east, or at Branford going west? I have myself, while observing the actual working of this regulation, been informed by a porter as we passed by the New Haven intake near Branford that he could not lock a closet as " there is somebody in it." The regulation is clearly ineffective and unworthy of modern industrial organization. It must be done away with, and that at the earliest possible moment.

As to the dropping of the excreta through the discharge pipe upon the roadbed, this, also, is a crude, unsatisfactory, and unsanitary way of disposing of excreta on trains. At best it necessarily soils the track and the trucks, for the section hands and others to walk or to work upon; it sometimes endangers public supplies of water; it always pollutes the air, and under some circumstances, by being carried by section laborers or others on their hands to their homes, endangers persons not immediately in contact with the roadbed or rolling stock.

But, it will be asked, what can be done about the matter? The answer is that the time has come when we must insist that if a railroad company finds it practicable to carry large iron tanks under passenger cars for gas or for refrigerator purposes, it can and must also carry there an iron tank for sewage. If for any reason this is impracticable, earth closets with pails frequently changed may be used. Railroads must somehow cease distributing fecal and urinary matters all along their lines. The closets ought not to be shut up, either at stations or anywhere else, so that the all-important personal hygienic requirements are defeated. The sewage tanks or pails could be emptied at selected places, either at the end of the run or, on long runs, at principal stations, precisely as water and gas are now taken into special tanks at principal stations. Of course there would have to be disinfection from time to time, and some trouble would have to be taken to see that the sewage tanks were kept clean and free from smells, but this could be done and ought to be done. At any rate, something different from the present crude, disgusting, and dangerous practice must be devised. And, where railroads run over or very near water supplies, as they often do and often must, if common decency and the comfort of the men are not enough to secure it, some provision must also be required for the convenience of freight trainmen. Upon wrecking trains and repair trains it would be easy enough to carry a portable closet, or a fixed privy with earth closet beneath, so that all excrements should later be carried off from the watershed and deposited at a distance.

I am aware, of course, that tanks underneath the cars would, in winter, be exposed to freezing, and that special pains would have to be taken to prevent this. It will not be as easy, certainly, to get rid of the excreta in a decent and scientific way, as it is simply to let them drop down through a hole in the floor; but we have got through dropping excreta in that way in our houses and hotels, and we must stop doing it in our traveling houses or hotels, that is, in our passenger cars. Water-works authorities, especially, must insist that whenever a railroad passes over a watershed it shall be subject to regulations regarding the discharge of excreta not less stringent than those which would be applied to an hotel or other place of public resort situated on the same watershed.

(As this paper is passing through the press, my attention is drawn to a newspaper statement touching another aspect of the sanitation of railway trains, namely, their garbage disposal:

"It was a surprise to me last week to see, just below the picturesque stone bridge which crosses the main street of ——, a trap for maladies of some sort, if not for typhoid. On the narrow roadbed, and almost covering the railway tracks, were strewn refuse of all kinds, soiled papers, fragments of cooking — in short, all the débris of human life that makes excellent food for pigs, with streams of dirty water forming pools that might sink into the soil eventually, but at present were stagnant. The spectacle gave me a jolt. It was so foreign to the general impression one receives of prosperous —— above ground, and it was wondered how such a garbage hole could ever be overlooked by the powers that be. No doubt this blot on the railroad banks has escaped the management's eagle eye."

Doubtless some of the employees upon dining cars and other departments of railway service look upon railways very much as some Americans look upon their streets, namely, as being practically waste baskets, garbage pails, and sewers. In all these matters our people are generally uneducated and careless. In the city of Boston the police commissioner has lately set a commendable example by ordering the arrest of all persons misusing the public ways in the manner just described, and a similar solicitude for the sanitary care of our railways on the part of railroad officials would doubtless effect a corresponding reform.)

APPENDIX A.

REPORT TO THE CHICAGO, MILWAUKEE & ST. PAUL RAILWAY COMPANY OF WASHINGTON, UPON THE SANITARY SITUATION CREATED BY THE PROPOSED CONSTRUCTION, MAINTENANCE, AND OPERATION OF ITS LINE THROUGH A PORTION OF THE COLLECTING GROUNDS OF THE PUBLIC WATER SUPPLY OF THE CITY OF SEATTLE.

BY JOHN W. ALVORD, CONSULTING ENGINEER.

At your request I have examined a large portion of the Cedar River watershed, the projected line of your railway, and the sanitary situation occasioned by its construction and operation. For this purpose, in company with Professor Bissell and Professor Pammel, of Ames, Ia., a week was spent in an examination of the territory in question.

During this trip we were accompanied by the division engineer of your company, Mr. Wilson, who pointed out the proposed location of the track from the company's plans and profiles. On Monday, the 16th of July, we entered the watershed by way of North Bend, examined the sanitary situation at the city's power house, and from thence drove up to the outlet of Cedar Lake, examining its shores in the vicinity of the outlet and at the outlet works in general. We then returned to the power house and commenced a detailed examination of the located line of your railroad from the power house to the city intake, measuring at frequent intervals the distances of the center line of the right of way from the water's edge, noting the soil conditions and other data. That portion of the line between the power house and Barneston is quite accessible for examination and was easily covered in the afternoon of the 16th.

DIFFICULT TO TRAVERSE.

We spent the night of the 16th at Barneston, and the next morning continued down the line of the right-of-way from Barneston to the city's intake. This portion of the line is inaccessible and difficult, the surveyors' line passing through heavy timber and dense underbrush and over many fallen logs and other impediments. The night of the 17th we spent at Ravensdale, and on the morning of the 18th took horses for Kangley, noting soil conditions, habitations and other data at that point, and the terminus of an interesting creek which lost itself in the porous soil just west of that station. We spent the night of the 18th at Barneston.

On the 19th we proceeded afoot by forest trail to the line of the Columbia & Puget Sound Railway, near Weyerhauser's logging camp No. 4. From there we proceeded to the Denny-Clay Company's works, the logging camps in the immediate vicinity, and the settlement at Sherwood. We continued from there to Walsh Lake and returned to Barneston that night. On the 20th we covered the territory drained by Taylor Creek, visiting Miller's logging camps Nos. 3, 5, and 6, also the intake and dam of the Barneston water supply on Taylor Creek and the shingle mill about a mile south of Barneston. On the 21st we noted the sanitary conditions around Barneston, and took the train for Seattle.

At the time the Seattle water works were first constructed I also visited this watershed in the interests of those who were expecting to take the bonds of the project, becoming fairly familiar with the topographic conditions of that section.

THE WATERSHED.

The watershed of the Cedar River above the intake appears to be one of the most extensive areas of porous soil utilized for natural filtration of a public water supply which it has ever been my fortune to observe. The glacial drift of which it is composed consists of coarse and fine gravels intermingled to a depth of some hundreds of feet. We looked in vain for traces of clays or finer soils. The surface mold is thin for the most part, and the level of the soil water on the benches and plateaus back from the river is evidently at a great distance below the surface, as indicated by the location of springs and the depth of the eroded streams. There is little or no surface run-off of the rainfall. Numerous potholes exist, depressions without visible outlet, and there was scarcely observed a dry run of any kind, or rivulet, save those of running streams, few in number, which were marked upon our map.

The unusual porosity of the soil may be best illustrated by the statement that in passing over the located line of the railway, eleven miles along Cedar River, no run or rivulet or surface indication of wash of any kind was observed leading into the stream, which would indicate that the rainfall passed over the surface of the ground. We also observed that in passing over the Northern Pacific Railway, which crosses the watershed from north to south, no pains were taken by that company to ditch its tracks, to provide small culverts, or even, in the case of very considerable depressions, to arrange for the passage of water from one side of its embankment to the other. The soil, therefore, of this valley is a porous one, receiving the copious rainfall of this region and largely absorbing it, and by slow percolation filtering it to an unusual degree, thus creating the clear streams and exceptionally pure water.

POPULATION OF THE WATERSHED.

As nearly as our inquiries could determine, the population of this watershed is about 1 500 people, mostly employees of the various logging companies living in camps and concentrated at certain points along the small streams which are tributary to the Cedar River. This class of population is perhaps not the most desirable from a sanitary point of view, and their environment and situation, as we saw it, is not attractive. The camps are serving generous quantities of food to the men, much of which is wasted, and in order to dispose of this refuse in any considerable camp a dozen or more hogs are kept and fattened from the garbage of the camp. The hog pens invariably extend into the running stream, so that the hogs may water there at will.

We observed contamination of this character at Miller's Camp No. 5, situated on the north fork of Taylor Creek. This camp is working at the present time about 60 men. The liquid refuse of the kitchen is delivered immediately upon the bank of the creek, and the hog-pen is situated so that the hogs have direct access and were observed fouling the creek. The creek has a flow estimated at from 4½ to 5½ cubic feet a second, and is distant from the intake approximately 15⅝ miles, measured along the flowing streams. Such flow measurements as we made indicated that the rapidity of the stream was in no case less than a mile an hour, and often exceeded 2 miles an hour, the fall being very great.

LOGGERS POLLUTE THE WATER.

At Miller's Camp No. 3, working now about 15 or 18 men, there were two privies and a garbage pile in the immediate vicinity of the stream, so situated as to pollute the same. An old, abandoned camp in the northern part of section 30, township 22, range 8 east, showed traces of pollutions in the vicinity of Taylor Creek in the shape of carcass remains, garbage piles, and privies. This camp was about 400 feet from the stream, however, the ground sloping down to the creek.

Miller's Camp No. 6, working 65 men, is situated upon a side hill a considerable distance from running water, the water supply being pumped up from a spring some 2 000 feet lower down upon the slope. Pollutions at this camp, which were similar in all respects to the other camps observed, would, therefore, not be a sanitary menace. At Kangley there are habitations and a sawmill, and the pollutions similar in all respects to the other camps observed were drained by a flowing brook running past the station. This stream pursues it's course to a point about one-half mile below the station, and although flowing an amount of water estimated at 8 or 10 cubic feet per second, disappears entirely into the porous soil and sink-holes in that vicinity.

At Weyerhauser's Camp No. 4, situated on a stream flowing about 5 cubic feet per second and running into Rock Creek, there is a logging camp, with some 6 bunk-houses located immediately over the brook, and garbage piles and privies immediately adjacent to the same. Below the camp a hog pen, containing 15 hogs, was so situated that the stream was enclosed, creating conditions which were far from desirable. The distance from this source of pollution to the intake, measured along the line of the flowing stream, is 5¾ miles.

At the Denny Clay Company's works we were told that there were about 100 men at work and probably 500 people in the vicinity. There are perhaps 25 houses of all kinds, besides the company's plant, including a considerable camp, sewered into a small rivulet flowing, at the time of our visit, perhaps 1½ cubic feet per second, and draining into Webster Creek.

Proceeding down to Walsh Lake we found upon its banks a log-loading outfit immediately adjacent to the mouth of Webster Creek. We observed at this point that the loggers themselves were not in the habit of drinking the water from this brook, but obtained their drinking water from a spring some twenty-five minutes' walk up the railroad. Walsh Lake has fairly good shores, although considerable decaying timber is found about the lake, as is the case with all other lakes and streams in this country. Three habitations were observed on the opposite banks of the lake which appeared to be occupied. Each habitation was provided with barns, etc., which apparently drained into the lake. Persons were observed bathing on the opposite shore of the lake. A little farther south from the outlet of Webster Creek is another log-loading outfit, working about 50 men. The outlet of Walsh Lake, meeting the stream which flows by Weyerhauser's Camp No. 4, forms Rock Creek, and at the junction of these two streams is situated Weyerhauser's Camp No. 2, containing, we are told, 85 men. The camp is situated 4½ miles above the city's intake, but owing to the lateness of the hour we were unable to visit this camp and obtain any data as to its sanitary condition.

POLLUTIONS AT BARNESTON.

The sawmill and camp at Barneston are situated upon an upper bench or bank, perhaps 600 to 700 feet distant from the edge of the river. The drainage of the benches at this point, if they may be said to drain at all upon the surface, is, generally speaking, away from the river, their elevation along the outer edge being higher than at a little distance back. While there is considerable pollution at Barneston and a large camp, it is probable that for the larger part it sinks into the soil and is well filtered before reaching the river. A considerable number of hogs and cattle, however, have free access to the water of Cedar River, and roam over the camp at will. Barneston is situated about 9¾ miles above the intake, measured along the line of the flowing streams.

Between Barneston and the power house the city of Seattle has constructed its pole line along the north bank of the river and somewhat closely following the same. For the purpose of access to this pole line, and probably originally for construction purposes, there has been built a road which follows the bank of the river, in places coming within 25 feet of the water's edge, giving full and free access to the river for the whole of its distance. Fishermen were observed trout fishing; remains of dinners were observed at the water's edge. Not far below the power house a considerable number of cattle were pasturing, which have ready access to the water of the river. A number of log jams in the river were noticed, and a great deal of decaying wood lines the stream banks, which, while common to this part of the country, is not usually considered a desirable feature of a watershed for public water supply. The sanitary conditions at the power house and the habitations there could not be criticised.

CEDAR LAKE.

The outlet of Cedar Lake was viewed. The lake appears, in many respects, to be an ideal one for purposes of water supply, the banks being for the most part steep. Near the outlet an extensive swamp borders the lake, filled with decaying wood and teeming with aquatic life. The premises of the keeper of the inlet works appeared to be properly protected, although 6 head of sheep were observed grazing about the outlet and having free access to the river. Fishermen were observed in a boat upon the lake, and the excrement of cattle upon the banks of the outlet. At one point, about 20 feet from the water's edge, human excrement was observed and noted. It is apparent that, while the conditions at this point are not serious, reliance is had fully upon the wildness and inaccessibility of the spot rather than upon any sanitary control.

The river between Barneston and the intake runs through an exceedingly wild and inaccessible region, and is very difficult of access. At only two points in this reach does the railroad line approach closely to the river, and at places it is from 900 to 1 400 feet away. No serious pollutions of any kind were observed upon this section; just above the dam of the intake there appeared to be an undesirable swamp on one side of the stream.

SUMMARY OF OBSERVATIONS.

Speaking generally, our impression was that the city of Seattle has an exceptionally good watershed, consisting of forest-covered mountain slopes and highly permeable soil, which forms, in the lower part at least, a great natural filter; mountain brooks, spring-fed and of great natural purity, freedom from permanent population, and a copious rainfall. These advantageous natural conditions, however, have not been protected, possibly, by want of adequate legal powers, but certainly by lack of suitable sanitary supervision. Many portions of the district being virtually inaccessible, much serious pollution is permitted which is probably, for the most part, unknown to the authorities.

There are about 25 miles of railroad now existing in the watershed. A considerable portion of this mileage is logging roads owned by private companies. Nearly all of these roads were traversed by us during our examination, and in no case did we see anything which seemed to us dangerous or menacing from their presence. The real menace which we observed lay in the conduct and character of the camps which were located upon flowing streams.

PROPOSED RAILROAD LOCATION.

The Chicago, Milwaukee & St. Paul Railway is proposing to enter the Cedar River watershed at or near the present power house, and traverse the valley to the intake along a line for the most part south of the river.

Ordinarily the presence of a railroad track and trains within a watershed is not looked upon by sanitary authorities as a menace when properly regulated. It is through the population and industries created by railroads that sanitary difficulties occur. Pains have been taken to investigate a considerable number of watersheds in this country which draw their waters from surface supplies, unfiltered either by artificial or natural means, and it is found that an exceedingly small proportion of cities are able to make the claim that no railroads exist upon their watersheds. Indeed, the question, so far as can be ascertained, has never before been raised as to the menace of the actual track and trains.

Following are some of the more important cities in this country which derive their supplies from surface sources, with the approximate mileage and number of stations upon their watersheds:

City.	Population in 1900.	Source.	Approximate Mileage of Railroads and Number of Stations.
New York, N. Y.	3 350 000	Croton River	45 miles railroad, 18 stations.
Boston, Mass.	560 000	Nashua River, Sudbury, and Cochituate	34 miles.
Baltimore, Md.	508 000	Gunpowder River	38 miles parallel, 41 stations on map.
San Francisco, Cal.	342 000	Lake Merced, mountain streams	None.
Providence, R. I.	175 000	Pawtuxet River	10 miles, 10 stations.
Kansas City, Mo.	163 700	Missouri River	Over 300 miles in immediate vicinity.
St. Paul, Minn.	163 000	Small lakes	No railroad.
Rochester, N. Y.	162 000	Hemlock Lake	No railroad. Summer resort around lake.
Denver, Colo.	133 850	South Platte	75 miles, 14 stations.
Worcester, Mass.	118 400	Lynde Brook	No railroad.
New Haven, Conn.	108 000	Mill River	35 miles, 10 stations.
Fall River, Mass.	104 800	Watuppa Lake	5 miles, 3 stations.
Omaha, Neb.	140 000	Missouri River	210 miles below Sioux City, 12 stations.
Scranton, Pa.	102 000	Roaring Brook, Oak River	10 miles.
Cambridge, Mass.	92 000	Stony Brook	5 miles.
Grand Rapids, Mich.	87 500	Grand River	260 miles, 70 stations.
Richmond, Va.	85 000	James River.	150 miles parallel, 92 stations.
Hartford, Conn.	80 000	(Brooks)	15 miles, 4 stations.
Trenton, N. J.	75 000	Delaware River	100 miles parallel.
Waterbury, Conn.	45 800	(Ponds)	No railroad.
Mobile, Ala.	38 400	Clear Creek	No railroad.

A very large majority of cities, therefore, have railways not only upon the watershed, but paralleling the streams from which their waters are taken, nor do the majority of such cities have excessive death-rate from zymotic disease, and, so far as I am aware, no criticism has ever been seriously raised that the presence, at least of the track and trains, in such cases constitutes a menace in any way. But there are sometimes not only practical reasons why precautions should be taken to insure the purity of water supplies, there are also esthetic reasons for guarding against contamination, and particularly in a case like the Cedar River, where preliminary arrangements are possible and where proximity to the flowing stream is close, it would seem wise that some precautions should be observed which would prevent the drainage from the track from directly entering the stream, or which would prevent those passing along the tracks from access to the stream in any way.

THE OPERATION PROBLEM.

The fact that a railroad will be constructed the entire length of the river from the power house to the intake, has advantages as well as disadvantages. It provides means of approach to the river at points where it is now inaccessible, but it also provides at the same time means for controlling the watershed and observing its condition, not only by the agents of the city, but by the observation of the general public as well, which means that public sentiment will by such means be created which will result in regulations, adequate police powers, and proper control. While, therefore, to some degree a railroad so located must of necessity increase access to the river valley, its presence is an efficient check on some forms of pollution which are now in progress and which have been undiscovered.

The precautions which would suggest themselves as desirable would be, first of all, at points where the track is in close proximity to the river, to so drain the roadbed from the cuts into the soil back of the fills that, if there is any possibility of surface wash, — a possibility of which I have seen no evidences so far, — it shall be carried back upon permeable soil to diked-in sink-holes, such as naturally abound all over this area, so that such drainage shall not directly reach the river. The drainage from the outer edge of the track may be intercepted by slightly widening the fills and forming a gutter, the waters from which can be led back to the inside of the track in the same way.

FENCE ALONG THE RIVER.

Secondly, a strong barbed-wire fence of adequate height might be constructed between the track and the river. Such a fence will, in my opinion, aid to control the situation and render it much less liable for passers along the track to defile the river in any way, or camp thereon without great difficulty.

Such a fence should be constructed by the city between the power house and Barneston along the right-of-way of its pole line, which would aid in excluding passers-by. This wagon road carries with it all of the menace of an operating railroad, and what has been said in reference to the drainage and precautions to be observed on the track of the railroad will apply with equal force to the city's own highway.

Suitable notices should be posted at frequent intervals upon such fence warning people from crossing it, just as fences with such rules are constructed around the reservoirs within the city. It is probable, of course, that malicious or ill-disposed persons will not be entirely prevented from violating the regulations of the city, but such persons have at the present time ready access to the river and stand no chance of even being discovered or controlled.

COVERS FOR BRIDGES.

The proposition of flooring the bridges with tight floors would meet with approval, and if it was thought desirable, at such points as the track necessitates, high fences could be erected to prevent the throwing of refuse from car windows directly into the river. The closets of the passenger coaches could be locked while traversing the watershed, as is ordinarily done now in traversing equal or greater distances through large cities and in all depot grounds.

These precautions should satisfy the most captious critic as to the security of the supply from the presence of the trains and track, and it might be suggested that they are much more adequate than are the provisions which are taken to guard against the contamination of the water in the city reservoirs within the city limits from thoughtless or ill-disposed persons.

THE CONSTRUCTION PROBLEM.

No great reservoir for a water supply is ever constructed without adequate sanitary precautions. In fact, in these days no great camp of men should ever be gathered together for any public work without adequate sanitary provisions. And it is, of course, evident that construction camps along the Cedar River for twelve to fifteen months, if uncontrolled, would create a situation far from desirable. To admit, however, that adequate sanitary control cannot properly and adequately meet the situation is to admit that we know little or nothing about sanitary control. The progress of sanitary science has been such in the last generation that we have come to a positive knowledge of new dangers which threaten the life and happiness of the general community, and with this knowledge has come also the knowledge of how to properly protect and guard against such dangers. The conduct of camps, the sanitary precautions to be taken in and about them, have been thoroughly studied, with the result that where intelligent authority has been permitted to exercise full sway, all dangers have been entirely eliminated.

RULES FOR CONSTRUCTION.

The precautions that should be taken in the construction of the railroad in Cedar valley would be primarily as follows:

First, the full and complete authority of a competent and educated sanitary officer, with suitable assistance.

Second, the provision for proper location of camps safely away from the vicinity of the river.

Third, care of the camps, so far as the health of the men is concerned, and provision for the purity of their drinking water and food supplies.

Fourth, the provision for suitable conveniences for the men at or near their work.

Fifth, the removal and destruction of human excrement.

Sixth, the removal and destruction of garbage and kitchen waste.

Seventh, the care of draft animals, collection of their droppings and its destruction.

Eighth, provision for bathing purposes.

SANITARY AUTHORITY.

Absolute and autocratic authority should be vested in the sanitary officer in charge of the district to formulate such rules and regulations as seem to him necessary for the control of the camps and of the men. It would be proposed as one of the most important of these rules that all actual access to the river be barred; that the wire fences before mentioned, separating the track from the river, be constructed at the earliest possible moment; such special arrangements should be made as will obviate all necessity or desire on the part of the men to visit the stream for any purpose whatever. Such men as refuse to conform to the regulations or show themselves indifferent to their importance, or wilfully disobedient, should be promptly ejected from the camps, and a strong authority should impress upon the working force the fact that sanitation requirements are the first consideration.

All sanitary authorities agree that the best disinfectant for all forms of human waste is fire. This is the safest and easiest method to adopt in a rough country such as we are considering, where fuel is plentiful. Suitable latrines should be built at very frequent intervals along the line of work. An inexpensive crematory can be easily excavated in the bank, consisting of a rough grating immediately over a fireplace, upon which the garbage and refuse can be burned, as well as the excremental matters. Collections in large camps should be made frequently, and in the outlying and more remote latrines at least twice each twenty-four hours.

Garbage and kitchen waste of the camps should be burned along with the excremental matters. Frequent collections should be made, and no such refuse should be allowed to stand, under any circumstances, many hours. The liquid waste from the cook houses should be led in drains to some safe point where a sufficient area of subsoil can be uncovered so that filtration will be effectually permitted.

Suitable provision should be made around all of the cook houses to prevent the ingress and egress of flies which might tend to contaminate the food.

LOCATION OF CAMPS.

Camps should be placed at distances at least 500 or 600 feet from the river, on land preferably level, or draining very slightly, if at all. Camps should be provided with a water supply, preferably from springs in the locality, or, if springs are not available. by water pumped up from the river in sufficient quantities for all purposes. It will be exceedingly desirable if the water supply of the camps can be placed under pressure, and suitable shower baths maintained for the use of the laborers, so that there is no desire as well as no opportunity or excuse for them to visit the river for any purpose. A physician should, of course, be provided, who shall watch the health of the men closely and carefully, and any case of sickness from any zymotic or intestinal disorder should be promptly removed from the watershed and all possible contamination carefully disinfected. Liberal quantities of disinfectants should be provided at every camp for the use of sanitary officers, and used under their directions.

SANITARY CONTROL OF CAMPS.

Men should be provided whose business it is to constantly keep the surroundings of the camps in a clean and presentable condition. All litter should be removed daily and burned, if possible.

Cleanliness in the bunk houses should be insisted upon. Personal cleanliness should be enforced, and persistently unclean employees should be debarred from the work.

Droppings from draft animals should be collected and burned in the same manner as human excrement. Draft animals should not be permitted to approach any stream entering the river, and always kept under full control.

IN GENERAL.

With these precautions properly taken there can be no question that all dangers of pollution to the water supply would be obviated, and that the water supply itself may be entirely above suspicion during all the time of construction. This statement is based upon the well-known efficacy of such regulations in the construction of great reservoirs, aqueducts, water supplies, even where such construction was proceeding above intakes already existing. It is also borne out by the experience of cities which purify their sewage and prevent contamination upon rivers, and it is substantiated by experience with military camps and military hygiene.

The history of the military camps has shown an increasing ability to control infection under most unfavorable conditions, and while our own volunteer army medical men did not during the Cuban War succeed so effectually as might have been hoped, they nevertheless learned a bitter lesson of the importance of such matters. Investigations of the conduct of the camps disclosed that important sanitary precautions had been entirely neglected. The typhoid which prevailed in the camps of the American army during the Cuban War is now attributed largely to the pollution effected by flies, which transferred objectionable matter from the latrines to the cook houses. And the lessons which were learned from that experience have been adopted by armies in all parts of the world so effectually that in the recent war between Japan and Russia the Japanese were practically enabled to completely annihilate this troublesome disease, as well as to reduce disease in general to the negligible minimum.

It may be remarked that the powers of a private corporation, backed by ample means and accustomed to secure efficient and capable service, unhampered by political influence or cumbersome checks, present an ideal instrument to carry out thorough and efficient sanitary control under proper supervision. So far as I can understand the situation, the interests of the railroad and the city are identical in considering this problem. Neither one nor the other can afford or should desire to trifle with matters pertaining to the public health. The attitude of both should be that of coöperation and diligence in seeking proper solution and acting on the best knowledge obtainable.

In conclusion, I believe that it is possible to construct a railroad in the Cedar River valley in a safe and sanitary manner, without a doubt. I believe, also, that once constructed, such a road, if operated without stations, with floored bridges and locked water closets, and with suitable fencing along the right-of-way, will present no opportunity for accidental contamination so great as exists at the present time. The presence of such additional men as it may bring into the watershed, due to its operation, will be, in my opinion, offset by the increased facility which it will give for patrolling the entire length of Cedar River, and for affording the authorities and the public an opportunity to observe the conditions of its source of supply. Dangers which might occur through careless control of the sanitary conditions of the construction forces can be met with proper diligence and intelligent supervision.

It would be quite idle to ask any physician in these enlightened days if he was able to enter a home where typhoid fever existed and successfully cope with the disease in such a manner that no danger to himself or other members of the family could ensue from infection. No reputable medical man would allow for a moment his inability to fully control the situation by suitable precautions founded on long experience and careful study.

The sanitary engineer is dealing with the same problem in a broader way; he is equipped with the same sort of information, the same sort of experience, and the same results of study, which enable him with certainty to control watersheds, water supplies, construction camps, and general conditions which make for the public health. And when authority and intelligence, combined with ample backing, are provided, this successful result has invariably been fully accomplished, just as the domestic problem of typhoid has been put under control.

CONCLUSIONS.

1. That in the Cedar River watershed the city of Seattle possesses a magnificent source of water supply.
2. That the city is not now and has not in the last few years properly protected this area from gross pollutions now existent.
3. That a virgin forest or inaccessible country does not afford ideal protection from pollution, but, on the contrary, a district easily accessible in every part and open to the publicity of frequent inspections and control offers the greatest degree of protection.
4. It is the settled policy, therefore, of most sanitary control of watersheds, while preventing as far as possible the growth of population and the incidental pollution therefrom, to open watersheds freely to the public observation, by creating means of access which facilitate inspection.
5. Railroads, so far as the track and trains are concerned, when properly regulated, are not regarded as a menace to the purity of surface waters by sanitary authorities.

6. It is through population and industries created by railroads that sanitary difficulties occur.

7. The 25 miles or so of railway now existing in the Cedar River watershed are in themselves no menace to the valley, but the logging camps which they serve are so conducted as to be serious pollutions in many cases.

8. That the operation of a completed railway line by the Chicago, Milwaukee & St. Paul Railway Company on or near the present location can be made entirely safe by some simple precautions, such as fencing, drainage, closed bridge floors and locked water-closets.

9. That care should be exercised during the period of construction of the railroad to prevent all access to the water by men or animals. For this purpose the river front should be entirely fenced off, policed, and, where necessary, water should be pumped up to the camps from the river under pressure, and in suitable quantities, for all purposes; including bathing and watering animals.

10. That efficient sanitary control should be had over all camps, cleanliness enforced, refuse of all kinds promptly collected and burned, drainage filtered and commodious and convenient sanitary arrangements provided, and strict control and authority maintained.

11. That the city of Seattle should also fence in the road which it has constructed along the river bank between Barneston and the power house, so as to prevent access therefrom to the river.

12. That the city of Seattle should regulate and control by intelligent sanitary rules the various logging camps now existing upon the watershed.

13. That it would be highly desirable to prevent decaying wood and vegetable matter from defacing the shores of Cedar River and its important tributaries, and to cut off the swamps at the outlet of Cedar Lake and immediately above the intake.

All of which is respectfully submitted.

JOHN W. ALVORD,
Consulting Engineer.

JULY, 1906.

APPENDIX B.

REPORT BY PROFS. A. C. ABBOTT, M.D.; CHARLES HARRINGTON, M.D.; AND WILLIAM T. SEDGWICK, PH.D., — A COMMISSION OF SANITARY EXPERTS,—TO THE CITY OF SEATTLE, THE KING COUNTY MEDICAL SOCIETY, AND THE CHICAGO, MILWAUKEE & ST. PAUL RAILWAY, ALL OF THE STATE OF WASHINGTON, UPON THE POSSIBILITY OF THE CONSTRUCTION, MAINTENANCE, AND OPERATION OF A RAILROAD WITHIN A PORTION OF THE WATERSHED SUPPLYING DRINKING WATER TO THE CITY OF SEATTLE, WITHOUT DANGER TO ITS INHABITANTS.

We have been asked to answer two questions: *First*, whether it is possible to construct a railroad within the watershed of Cedar River, between the water intake and the power house, without danger to the character and wholesomeness of the water supply of Seattle; and, *second*, whether, in the event of such construction, the road can be operated without endangering the public health of said city through pollution of the stream.

In order to acquire personal knowledge of all the relevant conditions obtaining in and about Cedar Valley, and thus to be able to submit replies based upon something more than general principles and *a priori* reasoning, we have made a careful examination of the area involved, paying particular attention to the configuration of the ground and to the nature of the soil, and we have extended our observations so as to include that part of the watershed between the point where the proposed road leaves it to enter the Snoqualmie watershed and the borders of Cedar Lake. The proposed location of the railroad, as indicated by stakes, has been followed practically from end to end, and the adjacent strips have been examined at such points and to such an extent as seemed desirable or necessary.

We have also carefully examined and considered the various statements and arguments submitted to us.

In view of all the facts, we have no hesitation in answering both questions in the affirmative.

The main question involved in both propositions is whether pollution of the surface of the proposed right-of-way and of the vicinity by the wastes of the human body can be prevented; and, if it cannot wholly be prevented, whether contamination of the river can be guarded against.

It is a well-established fact that sewage matters containing myriads of disease germs can be rendered quite innocuous by filtration through gravel and sand, so that, within a short time, and at a distance of but a few feet, the effluent water may have an entirely different character and yield only mineral evidence of its former bad qualities. This fact was the main reason for careful scrutiny of the nature of the soil.

It appears that, along much of the proposed location, gravel and sand are not to be found. The forest floor appears to be reasonably thick, but at most points it consists almost wholly of combustible matter, and where fires have occurred the soil is shown to be chiefly loose rock, with neither sand nor gravel, and consequently not porous and suitable for effective filtration. At some points along the route, clay and silt deposits are evident, but these materials are not suitable filtering media, for they do not permit percolation. In view of these facts, special provision will be necessary for proper disposal of such waste matters as may find their way to the surface of the ground within and near the limits of the right-of-way during construction and operation of the road; for without such provisions the said wastes would inevitably be washed into the river in times of heavy rainfall, and, in the event of their containing pathogenic organisms, might lead to disastrous outbreaks of infective disease. The fact is, however, that the character of the water can be adequately safeguarded by the adoption of methods which will be described in detail further on.

The safeguarding of the water supply during the construction of the proposed road is by no means a simple matter, for construction involves the introduction of large numbers of men into the watershed, whose wastes must be prevented from reaching the river. It will be necessary to establish camps at various places, and these camps must be supplied with water, must be drained, must be provided with bathing and laundry facilities and latrines, and in all respects must be under constant competent sanitary inspection and control far more stringent than, under ordinary conditions, is necessary. It is fortunate that a number of sites for such camps are available, at least 500 feet away from the river, on benches, where the soil, largely gravel, is dry and porous, and hence easily drained and entirely suitable for latrines. Two camps may easily be established outside the watershed; one below the intake, and one near the power house and just over the divide, within the drainage area of the Snoqualmie; and between these two points are the several sites above mentioned, on not more than two of which should camps be established.

At the several camps the necessary latrines should be board outhouses placed over reasonably deep pits for the reception of the discharges, which, out of abundant caution, should be disinfected by the application of milk of lime, made from freshly slaked lime, and kept protected from contact with the air. This should be prepared as often as twice per week, since with age it loses in causticity and germicidal power. As the pits become nearly filled, the filling should be completed with clean soil, and new ones should be dug. Between camps, other latrines should be established at intervals of a few hundred feet, and portable privies may be used, which frequently should be cleaned out and disinfected.

Rules relating to the use of these conveniences and absolutely prohibiting the discharge of human wastes elsewhere within the watershed should be enforced with great strictness and under penalty of dismissal. It will be necessary for the future needs of the section hands and others who will constantly be employed, and of the wreckers who may be brought in from time to time as one or another cause and occasion require, to establish privies at reasonable intervals; but for the last-mentioned a portable privy carried on the train, with watertight box or tank, would be preferable. Absolute prohibition of bathing and laundry work in the river must be emphasized.

In order that the stretch between the intake and the power house shall receive the minimum possible amount of human wastes, it is recommended that, while trains are in the valley, all closets be kept locked and that no stops be made except in emergencies, and that no station or round house be established between those points, even with the consent of the city of Seattle by ordinance, so long as the intake of the public water supply shall be below the present power house. Therefore we recommend the amendment of paragraph 2 of Section 2 of the ordinance granting the right-of-way, by striking out the words, " without the consent of the city of Seattle first having been granted by ordinance," and, further, by making the prohibition a permanent restriction in the deed.

For the most complete safeguarding of the water it is advised that, inasmuch as the soil between the location of the line and the river is frequently impermeable, and where made up of loose stone is devoid of the qualities necessary for slow filtration, the roadbed be trenched wherever necessary or advisable, the trenches being filled with gravel and sand, and that dikes be constructed alongside the trenches wherever necessary or advisable.

The necessary bridges should have steel decks, be ballasted with gravel and sand, and be provided with means for drainage, and the water drained off should be conducted to points at least 50 feet from the river bank on each side, and discharged over appropriate areas or into gravel pits.

During construction the entire area affected should be under the unhampered supervision and control of a competent sanitary engineer appointed by the city of Seattle and approved by the state board of health. He should be empowered to employ, with the approval of the state board of health, as many inspectors to act as sanitary police as the state board may deem to be reasonable, and he and they should be given all of the powers of special police. He should be required to employ one or more registered physicians as medical inspectors, who should examine and report to the board of health of the city of Seattle upon all cases of illness, and cause the immediate removal from the watershed of all persons found to be sick of infective disease.

We recommend, therefore, the amendment of paragraphs 3 and 5 of Section 2 of the ordinance granting the right-of-way, so as to provide for these measures of sanitary protection.

After construction and during operation, so long as water shall be taken from any point below the present power house, the roadbed should be under the constant supervision and control of a competent sanitary inspector appointed by the city of Seattle with the approval of the state board of health, and the section hands should be required to remove and properly to dispose of such obvious polluting material as may be discovered.

We feel that we should be remiss in our duty as sanitarians, although the matter is one beyond the scope of our employment, were we to neglect to call attention to the necessity of protecting the water supply of the city from possible dangerous pollution of far greater importance than any likely to be caused by the operation of a properly constructed and efficiently guarded railway.

The selection of the Cedar River watershed as a source of water supply was an eminently discriminating and wise act, inasmuch as Cedar Lake and the entire watershed are capable of yielding an abundant supply of pure, soft water. Especially commendable are the steps which have been taken to secure ownership by the city of the banks of Cedar River and Taylor Creek. But the city is apparently unaware of the fact that in using the water of an only partially protected running stream, without storage, it is exposing itself to the danger of a possible outbreak of typhoid fever or other water-borne infective disease. Contrary to common belief, founded on a mistake made by a commission who studied the subject of pollution of streams before the present methods of scientific examination were devised, the water of a rapidly moving stream does not lose its dangerous properties in a run of a few miles after it has received a specific contamination, and it is especially dangerous when this specific pollution has been discharged directly into it or has been washed into it before the action of sunlight and other agencies have destroyed the contained disease germs.

In the course of our examination, fishermen were observed here and there along the banks of the river, and in the woods near the stream were occasional evidences of occupation by camping parties. The danger of wholesale infection from the chance discharges of a single one of such trespassers is, indeed, slight; but it is a real danger, nevertheless, and when unrestricted access to the river is permitted, it becomes multiplied. We are informed that the city is taking steps looking to the abatement of local nuisances within the watershed, but we feel that it is not doing enough, and will not do enough, until fishermen and all others who have no real business along the city's water supply, or who are not under sanitary supervision and control, are warned off and dealt with as trespassers. Better yet would be the construction of a large impounding reservoir, between Cedar Lake and the power house, as proposed by the city engineer, and the bringing down of the water in mains from that neighborhood, thus gaining the advantage of a stored water.

Respectfully submitted,

A. C. ABBOTT.
CHARLES HARRINGTON.
WILLIAM T. SEDGWICK.

AUGUST 11, 1906.

APPENDIX C.

REPORT TO THE STATE BOARD OF HEALTH OF WASHINGTON UPON THE SANITARY ASPECTS OF A GRANT OF RIGHT-OF-WAY BY THE CITY OF SEATTLE FOR A RAILROAD ALONGSIDE THE STREAM FROM WHICH THAT CITY DERIVES ITS PUBLIC WATER SUPPLY.

BY JOHN R. FREEMAN, CONSULTING ENGINEER.

1. The question is: May the city of Seattle, with due regard to the public health, grant a right-of-way to the railroad in close proximity to the river above the city's intake for a distance of 10 miles, through lands acquired by the city for the protection of its water supply; particularly in view of the facts that this river flows rapidly and that there is no detention reservoir of size large enough to detain the water a sufficient time to permit germs of typhoid to die, and no filtration works to remove them?

2. My answer is that this right-of-way may be prudently granted if proper safeguards are provided, in rigorously caring for the construction camps, in moving the railroad location somewhat farther back from the river at certain points, in carefully designing culverts, bridges, and ditches, and by providing other safeguards to be described later in detail, and all of which I believe are entirely feasible.

3. The conditions surrounding the water supply of Seattle are, in respect to detention reservoirs, materially different from those at nearly all important cities that use surface water and have railroads, highways, and villages within their watersheds and retain a low typhoid death-rate.

4. A detention reservoir, in which water from the flowing stream must be stored for a month or more before passing into the distribution pipes, is one of the greatest of all safeguards in a surface water supply, and to cite the absence of injurious effects from railroads in watersheds from which the water is stored is mis-

leading as a precedent for Seattle in the proposed location of this railroad.

5. Seattle's water supply is in many ways one of unusual excellence; it is of a very remarkable transparency and freedom from color, and therein is probably not excelled by any large water supply in America and is equaled by very few. It is, in fact, mainly water flowing from springs.

In its selection and method of first development, excellent judgment and engineering skill are shown. Its few shortcomings are mainly those incident to newness and rapid growth and are such as doubtless will be remedied as the city grows, and as fast as the engineer is given the means. I learn that the city engineer has already outlined plans for its improvement, and I doubt not that this Cedar River source can be so improved and developed as to give to more than fivefold your present population one of the finest water supplies in the world. Plainly its purity should be jealously guarded.

6. The fundamental facts on which the answers to the present main question turn are the following:

7. If a single discharge from the bowels (or from the urine) of a person in the early or " walking " stages or the convalescent stages of typhoid fever falls into, or is soon washed into, any tributary of a flowing stream so that it reaches the distribution pipes of a city within a period of two or three weeks, the thousands or millions of the germs in this one pollution may become so scattered and diffused as to enter many households, and possibly finding lodgment in the intestines of those persons whose vitality or power of resistance is low, may bring disease to a hundred and death to a score or more of citizens.

8. The second important fact is, running water does not completely purify itself from disease germs. The three safeguards opposed to the above are:

9. *First*, that the chance is very rare of perfect connection of all the necessary links in the chain of circumstances between the dropping of the pollution and its seeds of disease being sown in the human system.

10. *Second*, that nature has a wonderful process of purification in natural filtration of polluted water by the wash from such material slowly through moderate depths of sand.

11. *Third;* that after a period of two or three weeks of immersion in stream or pond, most of the disease germs die, and that for most kinds of bacteria, sunlight is a great germicide. The coolness of this spring water, its running and aëration as it flows in this turbulent stream, all tend toward safety. The precise period of detention necessary for safety, the full list of water-borne diseases (which certainly comprises typhoid, dysentery, and cholera), and the life-history of these germs, present important problems not yet fully worked out by pathologists and bacteriologists, but we may believe the main facts stated above as proved beyond all doubt or question.

12. It appears well proved, also, that some kinds of disease germs survive drying and transportation in dust, but the greatest danger to a drinking-water supply lies in the water-borne germ, less than two or three weeks old, from the bowel discharge of a human being suffering with typhoid.

Lest some timid person be unnecessarily alarmed at the possibility, by not giving due regard to the probability, I venture a comparison with Providence, R. I., an old, wealthy, and cultivated city of substantially the same size as Seattle. It has for many years taken its water directly from the flowing stream into distributing reservoirs of moderate size, presenting only three or four days' detention, and not until within the past year have its filtration works been completed. The number of inhabitants per square mile on this Providence watershed is 315, which is nearly 100 times as great as on the Cedar River watershed of Seattle; and railroad lines with frequent local trains pass along the porous, sandy margin of its river, without thought of special protection or closing of closets, for distance aggregating more than 10 miles and with 7 bridge crossings. Its last typhoid epidemic was about seventeen years ago. This was traced to a case of typhoid on the watershed, but I have not the details at hand.

On the other hand, the possibilities of the number of cases for which one or a very few sick men can sow the seed, have been shown in a remarkable way at Plymouth, Pa.; Waterville, Me.; Windsor, Vt.; New Haven, Conn.; Ithaca, N. Y.; Chelmsford, Mass.; and elsewhere.

13. These facts have come to be understood and fully proved

only during the past ten to twenty years, through the profound and patient researches of a few small groups of bacteriologists, pathologists, and engineers, and unfortunately have not all of them yet become widely diffused as matters of common knowledge.

14. This is particularly true as regards the danger that may lurk even in the transparent, attractive water of a pure mountain stream that has become accidentally polluted.

DANGERS IN WATER SUPPLIES FROM RUNNING STREAMS WITHOUT DETENTION OR FILTRATION.

15. Years ago, before the recent science of bacteriology was born, a commission of English sanitarians, working from the chemist's point of view, was led to report that a flowing river did tend to purify itself and that its impurities became oxidized.

This is to some extent doubtless true. I doubt not that the water from Cedar Lake, with its many slowly decaying trees, stumps, logs, and weeds, is improved as it tumbles over its steep course of 10 miles to the intake, and that any deleterious effect of the jams of dead logs and tree tops along the stream is thereby lessened. Bad odors from decaying organic or vegetable material are shaken out and oxidation is promoted in water running over such a course.

The half-truth of stream purification became widely circulated and to-day continues to do harm, while 10 times over it has been proved that typhoid epidemics are so carried, and that from a single case along the tributary 100 or 1 000 citizens farther down the line may suffer.

16. It has been found by later studies that water that has been held long in storage is far safer than running water as a source of domestic supply, and the large new supplies of Boston and New York, for example, are being developed with reliance upon this principle of detention for protection against the unavoidable minor pollutions.

Other cities where detention reservoirs are impracticable, for example, Philadelphia, Pittsburg, and Providence, are now constructing great filter plants. So strong is the teaching of recent science and practice concerning the economic value of this safeguard that I venture the prediction that Seattle will ultimately, perhaps twenty years hence, come to filtration, unless later surveys shall demonstrate the feasibility of a large detention reservoir, or shall show that sufficient water can be taken by infiltration galleries or large wells directly from the remarkable series of springs which enter the river a few miles up stream from the intake.

For there are various possible sources of pollution already existing in this watershed, such as may produce typhoid, and while some are in process of remedy, others will continue or possibly increase during the many years of lumbering, regardless of whether the St. Paul road comes in or not; indeed, the beauty and attractiveness of this region will tend more and more as time goes on to bring sportsmen, fishermen, campers, and strollers into this watershed.

THE CITY'S WATERSHED.

17. It is only five years since the city of Seattle abandoned its unsatisfactory Lake Washington source and went back about 25 miles into the forests and foothills of the Cascade Mountains and built an intake and diversion dam on the Cedar River, at about 550 feet elevation above sea level, and from this point to the city constructed a wood-stave pipe hooped with iron, 42 inches in diameter. The diversion dam raised the river but little more than 15 feet and flowed back for so short a distance and so narrow a width that the time of detention in the pond thus formed is hardly more than two or three hours, with the mean annual rate of river flow, and not more than half a day at the time of minimum flow.

The city engineer gives the following data:

The city now takes out about 23 000 000 gallons daily, equivalent to about 35 cubic feet per second.

The population supplied, including certain suburban districts, is nearly 200 000.

The present per capita consumption is thus about 115 gallons daily.

The smallest flow of the river at the intake has been found in October, and in the year 1904 amounted to 154 cubic feet per second.

This minimum flow is 4.4 times the average quantity now drawn by the city.

In years of smaller rainfall a smaller river flow may be expected, but just how small cannot be stated from the data thus far collected, which are very scant.

The total watershed area above the intake is at least 139 square miles and may possibly be 145¾ square miles.

This is made up of two areas of different characteristics, although both are heavily timbered. The upper area is more within the mountains than the lower, and comprises a little more than half of the whole, its area tributary to the proposed future high dam being 75 square miles. All of this upper watershed is more than 1 500 feet above sea level and is nearly surrounded by mountains, which increase its average rainfall above that observed in the rain gage at the lake; so that this upper half of the drainage area received more than double the depth of rain that falls on the lower half of the watershed.

The record of 1904 gave for the total annual rainfall at Cedar Lake, at an elevation of about 1 530 feet, 94.4 inches.

The total inches of rainfall during the year 1904 at the intake at an elevation of about 550 feet above the sea was 48.6 inches.

When the whole area of 145 square miles is considered, it appears that the watershed is being rather slowly logged off, so that ten or perhaps twenty years may elapse before the lumber camps will be withdrawn.

The ground in those portions not yet logged is covered with a spongelike humus of decaying vegetation, probably 6 inches deep, which absorbs and restrains the rainfall from rapid run-off, but the fires that appear inseparable from lumbering as now conducted destroy this humus and leave the ground almost bare and sterile.

Cedar Lake for the upper portion, and the vast gravel deposits for the lower portion, will, however, continue to regulate the run-off from the watershed sufficiently for the city's purpose.

The city has already purchased about one tenth of the entire watershed, this being confined mainly to lands bordering on the streams and the lake. These purchases are in some cases subject to mineral rights and the possibility of future coal mines, and in some cases a right-of-way for future possible branch railroad lines has been reserved.

The city proposes to purchase additional areas as fast as these are logged off, and has arranged with the general government to have certain of the lands not yet sold withdrawn from sale, so that ultimately the city will own substantially its entire watershed.

It is of interest to briefly review the conditions of yield and storage for the purpose of learning if the intake at the water works could be moved up-stream.

The present temporary dam at the outlet of Cedar Lake gives at elevation 1 530 feet above sea level a storage reservoir of 1 300 acres area and 746 000 000 cubic feet capacity. A most excellent dam site that exists a mile or more farther down the stream will permit a high dam to be constructed, raising the level of the lake 60 feet, or to an elevation of 1 590 above sea, giving a storage reservoir of more than 6 times the present volume, or of 1 850 acres, and 4 835 000 000 cubic feet capacity.

This is equivalent to 36 000 000 000 gallons of storage, or half a year's supply for 2 000 000 people, without rain meanwhile.

Before one can state with certainty just how great a constant uniform draft this watershed can be made to supply, an extended study must be made of all Puget Sound rainfall records, and more observations must be had upon the rainfall and evaporation within this mountain region; and there may be remote possibilities of some escape by percolation through old channels filled with porous glacial deposits.

As a rough preliminary figure we can safely reckon that these two watersheds above the city's present intake will be sufficient for all reasonable uses of a population somewhere from 5 to 10 times as great as Seattle now possesses.

The lower half of the watershed, or that immediately up-stream from the intake, is said to be different from the upper in geological character, consisting mainly of a vast deposit of porous gravel, presumably an outwash plain from the mountains, or of glacial origin.

A comparison of the measured flow of the river near the intake with the flow at the outlet of Cedar Lake also brings out the characteristic difference of these watersheds.

While the natural yield from the upper watershed is said to fall to a minimum of about 30 cubic feet per second in August, the minimum flow at the intake dam is not reached ordinarily until October, and in 1904 was found to be 154 cubic feet per second, thus showing a yield from the lower 70 square miles at time of minimum flow more than 4 times as great as from the upper 75 square miles. Plainly the cause of this is the absorption of the winter's rains by the porous gravel deposit of the lower watershed to be stored and slowly given out by percolation to the many large springs near the bottom of the valley. These vast gravel deposits thus take the place of a storage reservoir for the lower watershed and increase its available yield.

18. It will be seen from the foregoing that to seek to avoid pollution by extending the city's intake pipe back to the power house, and thus virtually to the lake, would throw away nearly half of the available watershed area, and an area from which the water is rendered particularly transparent and pure by reason of its natural filtration. All of this watershed will be needed at some future time.

The higher dam would have to be built much earlier if the city's intake were extended farther up the stream, for the minimum yield from the upper watershed is stated to be, under present conditions, only 30 cubic feet per second, while the city to-day is using 35 cubic feet per second.

In view of the fact that the normal minimum yield at the present intake is 154 cubic feet per second, or more than 4 times as great as the present draft by the city, it will be possible to defer the expensive high dam for a number of years by continuing to draw largely from the lower watershed.

19. As the demand for power from the municipal power plant increases it will become more important to have a larger storage reservoir near the present intake than that which now exists.

The demand for power varies greatly at different hours of the day, but the delivery of the aqueduct to the city's reservoirs should be nearly constant. Wherefore an equalizing reservoir near the intake to the aqueduct will, at some future time, become necessary.

DETAILS OF PROPOSED RAILROAD LOCATION.

20. Coming now more into the details of the problem at hand, we find that the railroad, after running many trial lines, has finally staked out a line of location closely following the river for about 10 miles and twice crossing it, and also crossing the large tributary of Taylor Creek. This line runs in some places as close to the water's edge as the steep slope of the high embankment will permit, or so that the water would wash the foot of the steep slope, and riprap be required to hold it, but in general the center line will be nearly 100 feet distant from the water's edge, and for perhaps one fourth of the entire distance will be several hundred feet distant.

A view of the plan, showing the distance between the center line and the water's edge, does not tell the whole story of proximity unless one takes account of the width of roadbed and the width of the steep sloping embankment and of the somewhat nearer water line in time of flood.

21. The formation along the river near the desired location is mainly a vast glacial deposit, showing broad, deep terraces of gravel, for the up-stream 5 miles, but with apparently an increasing amount of bowlders and angular stones for the down-stream portion, so that as far as can now be seen before the ground has been cleared and burned, there will be a very scant bed of sand or fine gravel suitable for natural filtration of the wash from the roadbed along perhaps 2 miles of the line.

Within a distance of 2 or 3 miles up-stream from the intake are many flowing springs breaking out from under the terrace near the foot of the proposed railroad embankment, and the natural surface at the railroad center line is in many places moist, making it probable that when the railroad ditches are cut water will stand or flow continuously in the ditch beside the track at the foot of the inner slope.

22. It is plain from tramping along this railroad location line as now revised that an earnest effort has been made by the locating engineers to keep it farther away from the water than would be the custom under ordinary conditions, and it is plain that increased cost is already incurred in lessening the length of roadbed on

embankment sloping directly to the river, by moving the line farther back so that a considerable portion of the roadbed is in a cut.

23. But it is also plain that the line can, at somewhat further increase of cost, be pushed still further away from the river, and that in many places more of the roadbed can be made in shallow cut, so that there will be a natural earth dike between the roadbed and the river through which the natural drainage and rainwash will filter.

24. I am convinced that it is entirely reasonable for the city, as a condition of granting this right-of-way, to insist that the railroad be pushed back from the water to the very limit, and I find that the extra excavation thereby required will be mainly in gravel of loose, easy character, with some loose rock, but with little or no ledge, and the extra cost not at all exorbitant, so far as can be judged from the surface as now seen prior to clearing.

25. Many other precautions and safeguards not found in ordinary railroad construction should also be made a matter of definite agreement, competent inspection, and absolute enforcement, beyond the terms as they stand to-day in the ordinance granting the right-of-way. These will be described more in detail in the following pages.

In part it should be required that a dike of sand or gravel, say at least 3 feet high by 4 feet top width, be built and forever maintained between the roadbed and the river at all places where this is on the embankment.

Preference should everywhere be given to a roadbed in cut, so as to secure a natural dike, and, in brief, the most complete precautions should be taken regardless of expense, that any rainwash or polluting material falling on the roadbed will be safely filtered before reaching the flowing stream.

Although the chance of infection is small and remote, it is nevertheless possible and certain, and we may well remember the instance of Plymouth, Pa., for example, where it appears to have been proved that more than 1 000 cases of typhoid, with 114 deaths, resulted from the dejecta of a typhoid patient being thrown on frozen ground on the banks of a stream in a watershed that was almost uninhabited.

REASONABLENESS OF CEDAR RIVER LOCATION WITH SAFEGUARDS GUARANTEED.

First having a guaranty of the safeguards which can readily be provided and which can surely be enforced, I am led to conclude that the city of Seattle may prudently grant the desired right-of-way and that it would be unreasonable to withhold it, because of the waste in construction and operation that the best possible alternative railroad location involves, and for all of which waste the commercial interests of Seattle would ultimately have to help pay.

The risks in sanitation that will remain from the presence of the railroad after the prescribed safeguards are rigorously provided will, I believe, be of the microscopic and academic character that we continually have to accept; indeed, it can be figured out that the chance of pollution from the railroad after providing reasonable safeguards will not be one tenth as great as from other sources of possible pollution in lumber camps, sawmill settlements, strollers along the stream and in the branch railroad, all of which exist to-day and some of which will continue to exist indefinitely, and which, taken all together, are, after all, small in proportion to those that are found along the water supplies of many cities without serious epidemics.

Those fond of figures may be interested in the following computation:

Suppose 1 000 different passengers per day to pass through the Cedar River watershed on the St. Paul road; this is 365 000 per year. Health statistics of Massachusetts (the most complete in the United States) show 1.24 cases of typhoid per 1 000 inhabitants per year. Convalescents and those who have the disease in a mild form, in the first week or two of the disease, may travel. We can at most assume that 450 out of all these 365 000 passengers would have typhoid at some time during the year. Calling the duration of those stages of the disease within which one could travel a month, or one twelfth of a year, we can expect only 37 persons actually in the infectious stages will travel over the road during the year.

If these have so many as 4 stools per day, the chance is that in the twenty minutes (or one-seventy-second of a day) occupied by ordinary trains passing through the watershed, these 37 cases would produce: Thirty-seven cases multiplied by 4 stools, divided by 72, equals 2 stools per year on track; or the probability is that only 2 discharges per year of excreta from typhoid patients are likely to be dropped on this entire 10 miles of roadbed from passengers.

When we consider that one of the residents of a lumber camp sick with typhoid may have an average of say 2 stools per day (we have figured twice this for the passengers), or say at least 50 stools during his entire illness, this is 25 times as many as we figure out as likely to come from all the passengers in a year.

With 500 persons resident in the watershed, the probability is of only .62 cases of typhoid per year among them, and, of course, most of these residents are remote from the stream.

Figuring it in another form, and assuming the domicile in as close proximity to the stream as the track: A resident population of

$$\frac{2 \times 1\,000}{50 \times 1.24} = 32$$

persons would produce the same chance of infection that will be presented by 1 000 passengers per day on the trains.

26. I am told that the best alternative railroad location outside of the watershed or not alongside the city's source of water supply will require from 5 to 7 miles greater distance and necessitate a ruling gradient 0.25 per cent. steeper eastward for nearly 20 miles, approaching the mountain division, adding that much to the distance over which helper engines must run; and that, in addition to the greater length, sharper curves, which tend to limit speed, must be used, and that much more expensive trestles and high embankments must be built, and that some adverse gradient westward would also have to be incurred.

27. With the desired line down Cedar River valley, a continuous grade of eight-tenths of 1 per cent. can be secured and the curves need nowhere be sharper than 3 degrees, permitting high-speed passenger service with outer rail elevation adapted also for low-speed freight, and the lay of the land, its slopes and stream crossing nowhere invite slides or washouts.

POSSIBLE DANGERS TO BE GUARDED AGAINST.

28. The construction of this 10 miles of railroad alongside the city's water source introduces the following specific dangers to be guarded against:

(*a*) For about a year's duration construction gangs aggregating about 500 men will be employed along this 10 miles of river, thereby not only doubling the present total population, but placing all of these new men very near to the main stream. There will also be many camp followers and tramps.

(*b*) At the foot of the steeper eastward grade, near the city's power house, a station for helper locomotives will be established, with a round house and a few residences, which will increase as the business of the railroad grows. It is feasible to locate all of these buildings so that although located within 200 feet of the river their drainage can pass down an ancient channel into another stream, because of the very peculiar lay of the land at this point. But the bringing of this additional population brings more persons who will fish, hunt, or stroll along the nearby stream and who may chance to some time thoughtlessly pollute it.

(*c*) After the road reaches the operating stage, the passenger trains and freight trains will continually carry more and more, and with human nature as it is there will always be the chance of dangerous pollution dropped on the roadbed by those in the early stage of typhoid, dysentery, or other disease, in spite of the rules to lock the toilet rooms during the one-third or one-half hour occupied by a train in passing.

Freight trains and sometimes passenger trains will be detained on the long siding midway.

(*d*) From 6 to 10 section men will be continually engaged in maintenance work on this 10 or 11 miles of track close to the river.

(*e*) By opening up the country and making it more accessible to fishermen and sportsmen and picnickers, a railroad will be the means of bringing more people along the banks of the stream.

(*f*) Tramps, careless and reckless of regulations, will probably, in course of time, follow the railroad line.

(*g*) Double tracking or new bridges, wrecks or other work bringing in large gangs of workmen, are all likely to come in course of time.

29. The safeguards against the possible danger of pollution from the causes just described are all matters of simple care and common sense, all centering around the idea of keeping people out of the watershed or away from the tributary streams so far as possible, and of so placing camps, latrines, sidings, and main roadbed that the rain-wash from any defections or other pollutions will filter through a safe thickness of sand or fine gravel before it reaches the stream, and that all these localities shall be so far removed from the water or so shielded as to practically remove the chance of dust containing any of these germs from being blown into the water.

SANITARY OVERSIGHT REQUIRED.

30. The detailed specifications for much of this work cannot be properly made until the 100-foot right-of-way has been opened up and enough of the cut made to disclose the character of the ground for filtration, and whether flowing springs develop in the hillside districts; therefore the oversight of the whole matter should be placed with some competent sanitary engineer, working under authority of the city of Seattle and the state board of health, who should, from time to time, go over the line as construction progresses, in consultation with the chief engineer of the railroad, to frame such detailed specification as may be demanded by the character of the ground.

The supervising sanitary engineer should have his deputy continually on the ground during the progress of the work in the person of the chief sanitary inspector.

During the year of active construction this chief sanitary inspector will require the services of 3 or 4 deputies to look after the details of sanitation properly. At least one of these should be a physician skilled in the detection of typhoid and who should keep close watch of the health at the several camps. The entire line where work is going on should be patrolled twice daily.

After the construction period is over an inspection should be made at least once a month over the entire length of the railroad line of the St. Paul and also over the present Northern Pacific branch railroad. The sawmill village and the several lumber camps and the shores of the main stream all the way above the intake should also be inspected once a month by some one trained in sanitary science, and a record made on a carefully prepared blank, giving the conditions found, should be placed on file with the city water department.

31. Three or possibly 4 construction camps will be needed during the building of this 10 or 11 miles. Two of these camps can be located outside of the watershed, one at either end.

There are admirable locations for the 1 or 2 intermediate camps at points where the roadbed is located upon a bench several hundred feet back from the river.

32. Each of these 1 or 2 camps within the watershed should have its water supply piped in for drinking, cooking, and washing, and with hot water also on tap. This camp supply in general should be made more convenient than to visit the river for water. Deep pits should be dug into which all drainage from washing and cooking should be led to slowly filter away. Numerous light wooden privies that can be readily moved should be built and placed over pits, and these should be regularly disinfected by lime and slowly refilled with earth. A barbed wire fence of double strength should separate the camp from the river. Before occupancy the camp ground should be cleared of all trees and underbrush and the space between the camp and the river should also be cleared and burned for half a mile each way along the line so as to remove all cover.

Then with a sufficient number of sanitary inspectors and the prompt discharge of offenders, it will be entirely feasible to make the camp safe, as has been done on recent large work for the city of Boston close beside its water sources, where many foreign laborers were employed.

It should be made a part of the contract between the city and the railroad that any laborer, foreman, or other employee caught transgressing the sanitary rules will be immediately dismissed; and if one or more of the sanitary inspectors be given authority of a constable to arrest any offender against the health ordinance, it will help.

LOCATION OF RAILROAD FARTHER BACK FROM RIVER.

33. A relocation of the railroad line farther back from the river is the first work demanding attention.

To do this important work in the best manner and as a basis for laying out the further safeguards, a new survey map should be made on the scale of 100 feet to the inch, utilizing all present topographic notes and immediately putting surveyors in the field to extend the contours to cover with greater precision all of the ground between the road and the river and to reach up to the top of the terrace.

ENLARGED DETENTION RESERVOIR AT INTAKE.

34. The railroad grade may need to be placed at an elevation perhaps 20 feet higher (more or less) than it has yet been located, where it crosses the intake pond of the city water works, in order that the city may not sacrifice its opportunity to construct more of a detention and equalizing reservoir at the intake. Reference has already been made to its importance at some future time, for equalizing the irregular draft of water for power, so that it may be taken into the water supply conduit at a uniform rate, and whatever can be gained in detention of the water from the rapidly flowing stream before it enters the city's supply will be an advantage.

Surveys and studies on behalf of the city are needed to find out just how far such an enlargement of the present intake pond is feasible. The railroad's line as now surveyed is understood to permit little or no enlargement, and its engineers will naturally be opposed to raising the grade at this point.

Apparently no very good opportunity exists for a sufficient detention at the intake, this being complicated by the fact that the flood flow is many times larger than the city's present rate of draft; but this condition will change somewhat as the city grows and the Cedar Lake storage capacity is largely increased, and the matter is well worth the cost of immediate surveys and studies before the railroad makes the larger reservoir at this point forever impracticable.

CLEARING GROUND BETWEEN THE RAILROAD AND THE RIVER.

35. The trees should be cut, the logs removed, the stumps and dead wood burned, for the entire 100-foot width of right-of-way of the railroad. The ground between the railroad and the river

should all be similarly cleared and kept cleared, the object being to remove all cover and to permit easy inspection from the railroad and the prompt discovery of any trespassers.

The city, for its part, might also completely clear a strip 100 to 200 feet wide on the opposite bank, also for the purpose of removing cover and for making its sanitary patrol easy and efficient.

The value of shade for keeping the water more cool is mainly fanciful and far less than the value of the sun as a germicide. Ease of inspection is one of the greatest of all safeguards.

FENCING.

36. A barbed-wire fence should also be built along the inner boundary of the railroad's land as soon as the work of felling trees, burning and clearing is completed. This fence should be extra strong and tight, its object being to impede access to the water of tramps, railroad section men, or those who may leave the trains in case of accidents or detentions at sidings.

Should it be concluded that it is too much to ask for the maintenance of such a fence over all of this 10 or 11 miles, it should certainly be insisted upon for a strip nearly a mile in length near each construction camp and near the permanent siding.

CULVERTS.

37. Culverts, preferably of cast-iron pipe, of ample size, with tight joints, should be laid safely below frost, and for the entire 100-foot width of the right-of-way, for all small streams, flowing springs, and gulleys that give evidence of stream flow in time of rain.

An effort should everywhere be made to protect these small natural streams that cross under the roadway from any possible rain-wash of polluting material dropped on the railroad right-of-way by passenger, tramp, trainhand, or workman.

SIDE DITCHES AND DRAINS.

38. Where the railroad cut lies through moist ground, so that water percolates into the ditch on the uphill side, forming at times a running stream along the ditch, the ditch should be deepened

about 3 feet or more, according to circumstances, and have a width of at least 2 feet. In the bottom of this trench vitrified drain pipe, not less than 6 inches in diameter, and generally more, according to extent and length of water found, should be laid with open joints, surrounded and covered with coarse gravel for at least 1 foot in depth, and over this filled with fine gravel up to the ordinary form of a railroad side ditch. This drain pipe should be extended a sufficient distance through dry, porous gravel to permit the water thus collected to filter away through a safe distance of not too coarse earth before reaching the river.

39. There are several localities within this 10 miles where, so far as can to-day be seen, the ground will be found so rocky after the humus is burned off that it will perhaps prove unsuitable for filtering material. This is particularly true at several points within 2 or 3 miles of the intake. At such points the rain-wash from pollution dropped on the road ballast might fail of proper detention and purification unless ditches and drains are constructed as described in the preceding paragraph. It may, after further investigation, be found best to carry large drains of the type just described down stream from localities near the intake so that they will discharge below the watershed limits. The fact that the grade of the railroad descends without interruption at the rate of about 40 feet per mile for the entire distance of 10 miles makes drains of this kind feasible.

The details of side-ditches and vitrified pipe drains and the gravel covering them will have to be studied out on the ground after its character has been more fully shown up by clearing off the timber and dead wood, burning off the humus, and making the main cut.

SIDING.

40. Only one side track for passing trains is desired within this 10 miles. An excellent site for this is found on a high bench or terrace of gravel nearly opposite the sawmill village of Barneston. At the site of this siding the railroad line should be crowded against the hill so as to give greatest possible distance from the river. By so doing a distance will intervene that can be regarded as entirely safe.

To provide against possible pollution during the long detention of freight trains here, 3 or 4 small, neat privies should be constructed along the line over pits dug deep in gravel, and the whole properly cared for as part of the regular maintenance work of the section gang.

Here and at all tool houses for the section gangs it may not be amiss to pipe from the small spring on the hillside so as to give a convenient drinking-water place, and to lead the drainage therefrom into a blind drain in the porous gravel.

A location about a mile below Barneston also furnishes a favorable site for one of the construction camps and for a tool house and headquarters for the section gang.

The ordinance should forbid any regular station on the railroad within the watershed.

SECTION GANGS.

41. After the railroad construction is finished and the road is in operation, its maintenance will require the continual services of, say, 1½ section gangs for this 10 miles.

It can doubtless be arranged that only 1 gang will have its headquarters and its tool house within the watershed limits, while the ends are cared for by the gangs domiciled just outside.

Conspicuous notices, in large type, should be placed in all the section tool houses for each of the 3 gangs that work within this watershed, directing attention to the preservation of the purity of the city's water supply. Small, neat privies over deep pits should be maintained, at convenient intervals, for the section gangs along the entire 10 miles of road within the watershed, to the satisfaction of the city's sanitary inspector, and the section men should be instructed to bury, immediately, any polluting material found on the track.

BRIDGES.

42. It is already prescribed in the ordinance that the bridges are to be tight deck bridges. The St. Paul road crosses the main river twice within the watershed and makes an equally important crossing of Taylor Creek, which is also a large, rapidly flowing stream.

It would be almost impracticable to secure by ordinary methods of railroad bridge construction a deck so tight that heavy rain would not wash pollution through it or around the end of its parapet back into the stream.

Special care, therefore, must be given. My recommendation is for a reinforced concrete arch bridge at each of these 3 important crossings, having the top of its arch, say, at least 2 feet below the bottom of the ballast and with a space over the arch filled with moderately coarse porous sand, such as will afford good filtration.. The side parapets should be carried up 4 feet above the rail and extended for at least 50 feet into the bank beyond the high water line.

The smaller creeks and the channels that run strong in time of heavy rains should each be the subject of a somewhat similar precaution.

HELPER-ENGINE STATION.

43. Near to the city's electric power station, but just outside the city's watershed, there will be located a small round house for locomotives used to help trains up the heavier eastward grade that begins near this point. The lay of the land here is so peculiar that, although distant but a few hundred feet from Cedar River, all of these buildings can be made to drain outside the watershed, and the only danger is that as business grows and the station becomes larger, men off duty, or members of their families, will stroll along the river and might thoughtlessly pollute it. It will doubtless be sufficient for the city to require the maintenance of an extra strong and tight barbed wire fence along the railroad location here, and to post conspicuous notices asking for thoughtful care in preserving the purity of the water.

ANTI-POLLUTION NOTICES.

44. It will be useful for the city to prepare a large number of conspicuous notices, printed on cloth in very coarse type, briefly asking the coöperation of all who walk along these portions of the river to lend their aid in preserving the purity of the city's drinking water supply, and to nail these to posts and trees all along the line of Cedar River, and also along those creeks and valleys that pass near to the lumber camps.

Such a request for friendly aid will doubtless be as efficient as posting copies of the health ordinances with a description of the penalties.

LOCKING OF PRIVY DOORS ON CARS.

45. Representatives of the railroad have offered the suggestion that the closet doors could be locked during the times that trains are passing over this 10 or 11 miles of track within the city's watershed, and, perhaps relying on this safeguard as sufficient, had not proposed such extensive structural precautions as I have outlined above.

It appears certain to me, after careful consideration of the known facts regarding typhoid and of the epidemics that have been plainly traced to pollution of a flowing stream, that the safety of the citizens of Seattle demands the more certain, although much more expensive, safeguards herein recommended.

The time of crossing the watershed by a passenger train on an up-grade might often be nearly half an hour, and for a freight train the period would be longer, and still longer periods within the watershed are probable in case of detention at the siding waiting for a belated train, or while waiting for a clear track after a wreck.

Persons coming down sick or homeward bound with typhoid or dysentery, or in the early and unrecognized, but infectious, stages may be among the passengers, and it is too much to expect or to require that the door would always be kept locked against urgent need.

Detachable pans under the car closet may possibly, at some future time, come into use, as is now being done on some German railroads, but it is too much to expect that their use could be relied on on all sorts of cars on this 10-mile run between unimportant stations out in the woods. The only safe way is to safeguard the roadbed construction on the theory that closets will often be left unlocked, and then add to the safety by keeping them closed as much as can properly be done.

REMEDY OF EXISTING POSSIBLE SOURCES OF POLLUTION.

46. My own examination was confined to the proposed St. Paul railroad line and the territory adjacent thereto.

Whatever chances of pollution may exist to-day, these are plainly no justification for an increase in the chance of pollution, and therefore I did not consider that the present question required me to seek out the various settlements in the watershed or to inspect the lumber camps, but at Barneston our party spent the night, and thus had opportunity to note existing conditions.

I am told that there are now about 500 persons resident within this watershed. This is a remarkably small number per square mile as city watersheds go, and would not give rise to serious apprehension except for the fact that the city takes its water directly from the rapidly flowing stream and that a part of this population, at least, resides in undesirable proximity to rapidly flowing tributaries.

At Barneston the village of the Japanese sawmill laborers, in time of heavy rains, now drains directly into Cedar River, but I am told that new houses for these laborers are already approaching completion and that present houses and privies will soon be torn down. So in the lumber camps and elsewhere doubtless improvement will be the order of the future, and the chief sanitary inspector that the city employs on this railroad work may, during the year of railroad building, very properly extend the scope of his inquiry and study of improved conditions throughout the watershed.

INVESTIGATIONS FOR IMPROVEMENT OF SUPPLY.

47. With the best sanitary inspection that is practicable a rapidly flowing stream will always present some remote chance of danger, and therefore I am led to earnestly recommend that the city engineer make, in the immediate future, a sufficient reconnaissance both for the enlarged detention reservoir at the intake already mentioned and also for learning just what opportunity there may be of securing a supply sufficient for the present needs of the city from the remarkable series of large cool springs within 2 or 3 miles of the present intake. An inspection of the map of the watershed boundaries gives small hope that these springs will suffice for anything more than a temporary supply, but the present is a good time for reviewing all of these possibilities and for making full and precise measurements that will be very useful in all future studies.

FISHING.

So long as no detention reservoir exists and the water is without filtration, fishing along Cedar River above the city's intake may well be prohibited, not on account of the fishing, but simply as one more means of lessening the chance of a man in the early and unrecognized stages of typhoid strolling along this stream. Even the spit of one coming down with typhoid is said to contain the germs of the disease, and the typhoid bacillus sometimes continues to be found in the urine for several weeks after the patient is so far convalescent as to be walking around.

SWAN LAKE AS A DETENTION RESERVOIR.

A part of the chief engineer's original plans was to provide a period of detention of the Cedar River water in Swan Lake. This lake is reported to have been found containing large quantities of wild fowl guano at its upper end, and it is also stated that the elevation above sea level is somewhat smaller than desirable for economy in size of aqueduct to the higher levels of the city.

In view of the well-known possibilities of danger in taking water from a flowing stream, I venture to suggest that this whole matter of Swan Lake and other possible sites for a detention reservoir should be carefully studied anew.

The expense already incurred by the city in securing a sparsely settled mountain watershed, and in systematically beginning to purchase the fee to the entire area as a means of excluding pollution, the excellence of this gathering ground, its sufficiency for the city for many years in the future, the great importance of a supply of water pure beyond suspicion as an asset in encouraging the city's growth, all concur to make this question of avoiding any new source of pollution paramount.

The one death per thousand inhabitants per year from water-borne typhoid may as easily be the foremost citizen as the humblest.

Respectfully submitted,

JOHN R. FREEMAN,
Consulting Hydraulic Engineer.

AUGUST, 1906.

PROCEEDINGS.

NOVEMBER MEETING.

HOTEL BRUNSWICK,
BOSTON, November 14, 1906.

President William T. Sedgwick in the chair.

Before the members took seats, a toast was drunk in silence to the memory of Freeman Clarke Coffin, whose funeral fell on the day of the meeting.

The following members and guests were in attendance:

MEMBERS.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, J. E. Beals, F. D. Berry, J. M. Birmingham, J. W. Blackmer, E. C. Brooks, G. A. P. Bucknam, George Cassell, C. E. Childs, J. C. Chase, R. C. P. Coggeshall, M. F. Collins, W. R. Conard, M. J. Doyle, C. R. Felton, Desmond FitzGerald, A. N. French, F. L. Fuller, J. C. Gilbert, A. S. Glover, J. O. Hall, L. M. Hastings, V. C. Hastings, T. G. Hazard, Jr., D. A. Heffernan, H. G. Holden, J. L. Howard, Willard Kent, G. A. Kimball, G. A. King, Morris Knowles, E. E. Lochridge, Thomas McKenzie, Hugh McLean, H. V. Macksey, D. E. Makepeace, A. E. Martin, W. E. Maybury, John Mayo, F. E. Merrill, H. A. Miller, Wm. Naylor, F. L. Northrop, J. H. Perkins, W. W. Robertson, E. M. Shedd, G. A. Stacy, J. A. Tilden, A. Townsend, R. J. Thomas, H. L. Thomas, W. H. Thomas, J. L. Tighe, D. N. Tower, W. H. Vaughn, C. K. Walker, J. C. Whitney, F. E. Winsor, G. E. Winslow. — 61.

HONORARY MEMBERS.

W. T. Sedgwick, F. W. Shepperd. — 2.

ASSOCIATES.

Ashton Valve Company, by C. W. Houghton; Harold L. Bond & Co., by Harold L. Bond; Hersey Manufacturing Company, by Albert S. Glover, J. A. Tilden, F. A. Smith, W. A. Hersey, H. V. Macksey; International Steam Pump Company, by Sam'l Harrison; Ludlow Valve Manufacturing Company, by H. F. Gould; H. Mueller Manufacturing Company, by O. B. Mueller and Geo. A. Caldwell; National Meter Company, by Chas. H. Baldwin and J. G. Lufkin; Neptune Meter Company, by H. H. Kinsey; Perrin, Seamans & Co., by Chas. E. Godfrey; Rensselaer Manufacturing Company, by Fred S. Bates and C. L. Brown; A. P. Smith Manufacturing Company, by F. N. Whitcomb; Platt Iron Works Company, by F. H. Hayes; Thomson Meter Company, by S. D. Higley and E. M. Shedd; Union Water Meter Company, by Edw. F. King and F. L. Northrop; United States Cast Iron Pipe

and Foundry Company, by F. W. Nevins; R. D. Wood & Co., by Wm. F. Woodburn; Water Works Equipment Company, by W. H. Van Winkle. —26.

GUESTS.

George H. Finneran, Thomas A. Lennon, Boston, Mass.; E. L. Harvell and John H. Burke, water commissioners, Rockland, Mass.; A. W. Danforth, Reading, Mass.; Dr. Benj. P. Wall, Berkeley, Cal.; Arthur E. Blackmer, superintendent, Plymouth, Mass.; Wm E. Bailey, commissioner, Beverly Mass.; H. O. Brooks, Lowell, Mass. — 9.

[Names counted twice — 6.]

After luncheon had been served, and before the opening of the regular exercises of the afternoon, an informal address of thanks was made by the President, on behalf of a large number of active and associate members of the Association, accompanied by the presentation of a gold watch, duly inscribed, to Mr. Frank E. Merrill, whose services in connection with the annual convention at Fabyans, N. H., were not only untiring and self-sacrificing, but highly appreciated. Mr. Merrill, to whom the presentation came as a complete surprise, made a response accepting the gift with hearty thanks and expressions of satisfaction in the kind feelings which prompted it.

Applications for active membership by the following-named persons, properly endorsed and recommended by the Executive Committee, were presented by the Secretary:

William C. Lounsbury, Superior, Wis., bacteriologist and chemist for the Superior Water Company; Henry A. Symonds, Athol, Mass., superintendent water works; George H. Finneran, Boston, Mass., chief clerk distribution division, Boston Water Department; Andrew S. Corr, Phillipsburg, N. J., inspector of cast-iron pipe for gas and water companies, and water-works materials for various cities and corporations; Hardolph Wasteneys, Brisbane, Australia, chemist to the Brisbane Water Works and director of laboratory; C. P. Nibecker, Pittsburg, Pa., connected with the operation of filter plants for the American Water Works and Guarantee Company; Edgar A. Cate, Everett, Mass., in charge of water income and department accounts; Elton D. Walker, State College, Pa., professor of hydraulic and sanitary engineering, and expert for Pennsylvania State Department of Health.

On motion of Mr. Coggeshall, the Secretary was instructed to cast one ballot in favor of the applicants, and he having so done they were declared regularly elected members of the Association.

The President read the following minute adopted by the Executive Committee and ordered to be presented to the Association for its action:

" It has come to the knowledge of your Executive Committee that the appropriation for the gaging of streams and other investigations of the water resources of the United States by the United States Geological Survey was reduced at the last session of Congress by the large amount of $50 000, this being one fourth of the whole sum previously appropriated. We learn also that some of the congressmen from New England were active in bringing about this reduction. We therefore recommend that the following minute be adopted by the Association and spread upon its records, and that a copy of the same, signed on behalf of the Association by the President and Secretary, be mailed to every member of Congress from New England.

" 'The New England Water Works Association has learned with regret that a reduction of $50 000 was made at the last session of Congress in the appropriation in the Sundry Civil Bill for the work of the United States Geological Survey in the gaging of streams and other investigations of the water resources of the United States. The Association believes that this reduction was uncalled for and has already done harm. It desires to place on record its appreciation of the hydrographic work of the United States Geological Survey, and its earnest hope that the members of Congress from New England will exert themselves to see to it that the reduction be not continued beyond the present year. It believes that the industrial progress and the sanitary welfare of the people of New England largely depend upon the conservation and development of their water supplies, and it commends the judicious activity of the United States Geological Survey in making stream measurements, investigating the pollution of interstate rivers, and, in general, in seeking out and making known the water resources, not only of New England, but of the whole country.' "

Mr. Frank L. Fuller moved that the minute as read be accepted and adopted. Carried.

Mr. Robert J. Thomas called attention to the vacancy in the list of nominees for officers for the ensuing year presented by the Nominating Committee, caused by the death of Mr. Freeman C. Coffin, who was named for one of the vice-presidents, and moved that the same committee be authorized and instructed to make a new nomination to fill the vacancy. The President stated that the constitution does not make definite provision for a contingency of this sort, but if the motion were passed without objection it ought to have all the force of law and the constitution. Adopted.

The President again expressed his great desire that at the meetings of the Association a larger number of practical experience papers should be presented than has been customary in recent years. Speaking upon this subject, he said:

" As many of you know, I have been anxious that we should have at our meetings a greater number of practical papers by the water-works superintendents of New England. We find it easy enough to get learned, scientific papers, and we want these. It has been the glory of this Association that it has had so many such papers, and that some of the most important original articles of the day in water-works science have been read at our meetings and published in our JOURNAL; but for a large majority of our members actual experience papers would be of no less, and perhaps even greater, interest. Your officers, however, have no way of arranging for such papers unless these are volunteered by communications from individual members. If any man is having trouble with any particular problem, and is willing to talk frankly about it, and get advice from his fellow superintendents, let him drop a note to Mr. Kent and say he would like to talk for five minutes or more on such or such a subject. We shall welcome suggestions of that kind, and I am particularly anxious that the coming meetings, if we can arrange them so, shall be devoted largely to such discussions. To-day we have the more scientific and more learned papers, so-called, but we ought to have at about every other meeting practical papers also. dealing with the difficulties that practical men are encountering from day to day. If there is a judicious mixture of the two kinds of papers, the Association will go on to even greater successes than it has attained hitherto, while if it gives itself up wholly to either alone it will surely fail of accomplishing the best results. So we beg any one of you who has in mind any topic he thinks it would be interesting to have discussed, to write to Mr. Kent or to me or to any member of the Executive

Committee, and we will try to arrange for its discussion and see that it goes off well."

The first paper of the afternoon was by Mr. Charles R. Felton, city engineer, Brockton, Mass., and was a " Description of Brockton's New Water Works," illustrated by stereopticon views. Remarks were made in connection with the paper by Mr. Desmond FitzGerald and Mr. Morris Knowles. The second paper was by Mr. L. M. Hastings, city engineer, Cambridge, Mass., entitled " A Study of Some Vital Statistics." This, also, was illustrated, and the discussion was participated in by President Sedgwick, Mr.. Desmond FitzGerald, Mr. Morris Knowles, Mr. Frank L. Fuller, Mr. Hiram A. Miller, Mr. Robert J. Thomas, and Mr. Charles R. Felton.

Adjourned.

EXECUTIVE COMMITTEE.

Tremont Temple, 11.30 A.M., November 14, 1906.

Present: President William T. Sedgwick, and John C. Chase, Robert J. Thomas, James L. Tighe, George A. Stacy, Lewis M. Bancroft, Frank E. Merrill, and Willard Kent.

Eight applications were received and the applicants recommended for membership.

Eulogistic remarks were made on the life and character of our late associate, Mr. Freeman C. Coffin, and the committee on nominations of officers of the Association for the coming year were requested to fill the vacancy in the list already issued caused by his death.

The question of place of next annual convention was discussed, and on motion of Mr. Chase, seconded by Mr. Tighe, the subject was referred to the next meeting of the Executive Committee.

On motion of Mr. Stacy, seconded by Mr. Tighe, it was voted:

That the Executive Committee recommend to the Association that the Association express its regret at the action of Congress in reducing the appropriation for the measurement of streams, etc., by the United States Geological Survey.*

Adjourned.

WILLARD KENT, *Secretary.*

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* See minute as printed on page 489.

OBITUARY.

William Winslow Burnham died in the Wilmington, N. C., hospital, August 11, 1906, of typhoid fever, after an illness of seven weeks.

Mr. Burnham was born in Biddeford, Me., August 24, 1875, graduating from the Biddeford High School in 1892, and from the sanitary engineering course of the Massachusetts Institute of Technology in 1903. Immediately after graduation he obtained a position in the engineering office of the Massachusetts State Board of Health, which position he resigned June 1, 1904, when he accepted an appointment to the United States Geological Survey, Hydrographic Division. While in this position his work involved the determination of the depth of ground waters over the desert region known as Carson Sink. He was also connected with the Truckee-Carson irrigation project which the government is now constructing in Nevada. In the fall of 1904 he made a survey of the surface and artesian waters of Georgia, which completed his work with the United States Geological Survey.

February 1, 1905, he became the engineer of the Hugh MacRae Company of Wilmington, N. C., with which company he remained until his death.

Mr. Burnham was married, March 6, 1906, to Miss Ella M. Cate, of Malden, Mass.

He was a member of the Boston Society of Civil Engineers. He was elected a member of this Association on September 13, 1905.

Freeman Clarke Coffin, civil engineer, died at his home in West Medford, Mass., on November 11, 1906, after a brief illness.

Mr. Coffin was born in Boston, September 14, 1856, but while he was very young his parents moved to Patten, Me., where he received his early education, and later started in the manufacture of furniture. In 1882 he came to Boston and entered the employment of the Coffin Valve Company, of which his uncle was one of the managers, as a pattern maker, but seeing no opportunity to rise in this work looked for engineering employment, and after two years entered the office of the late M. M. Tidd. Mr. Tidd was at that time probably better known as a water-works designer and builder than any other engineer in New England.

Up to this time Mr. Coffin had had no training or experience in engineering work, and he was then twenty-eight years of age. Nevertheless, in about two years he became Mr. Tidd's principal assistant. He remained with Mr. Tidd about ten years, and in 1894 started in business for himself, making a specialty of water works and sewerage systems. During the twelve years he was in business he constructed many such systems in the United States and Canada, and also acted as expert in a number of water-works valuation cases.

A few years ago he published a valuable handbook entitled "Graphical Solution of Hydraulic Problems."

The high position attained by Mr. Coffin in his profession is too well known by the members of this Association to need amplification here. At the time of his death he was the senior vice-president of the Boston Society of Civil Engineers, and chairman of the Sanitary Section of that society. He was also a member of the American Society of Civil Engineers, and of the Canadian Society of Civil Engineers.

Mr. Coffin had much to do with inaugurating and carrying out a great deal of the most important technical work done by this Association. A brief paper entitled "A Few Notes on Cast-Iron Pipe," presented by him in March, 1900, published in the JOURNAL for September of that year, suggested the preparation by this Association of standard specifications for cast-iron pipe;

as a result a committee was appointed, with Mr. Coffin as chairman, which, after a great deal of work, gave us our present admirable standard specifications. Later, as the result of a brief paper presented by him in January, 1904, a committee on meter rates was appointed, with Mr. Coffin as chairman. For the committee he opened a topical discussion on this subject at the March, 1904, meeting, and submitted progress reports at the 1905 and 1906 conventions. This committee is still in existence.

Mr. Coffin had also presented to the Association a considerable number of papers. Among the most important of them may be mentioned the following:

" Standpipes and Their Design," 1893; " Financial Management of Water Works," 1896; " Friction in Several Pumping Mains," 1896; " Application of Gas, Gasoline, and Oil Engines to Pumping Machinery," 1899; " Covered Reservoirs and their Design," 1900.

He had never held office in this Association, but had just been nominated for one of the vice-presidents for the year 1907. He was elected a member on February 13, 1899.

BOOK REVIEW.

Quasi-Public Corporation Accounting and Management. By John F. J. Mulhall, P.A. Boston: Corporation Publishing Company. Half morocco, 6¼ x 9½ inches. Pp. 203. Price, $5.00.

This book treats principally of the accounts and other records which should be kept by public-service corporations, including water, gas, electric light, steam heating, telephone, and electric railway companies. Two brief chapters are devoted to the formation of corporations and information relating to stocks and bonds, with examples of stock certificates, bonds, coupons, trust deeds, etc. The remainder of the book is devoted to the forms of accounts, records, etc., needed in the operation of such a corporation.

Water works are first taken up, and are treated at greater length than any of the other kinds of public-service works. This is, however, because many of the forms required are substantially the same for all such systems, and the principles having been once set forth under the head of water works, it would be mere repetition to present them again in detail under each of the other kinds of works.

Copies of all the important forms are given, in most cases illustrated by cuts showing actual forms on reduced scale. Methods of keeping the customers' accounts, as well as the ordinary accounts of the company, are explained. A part of this section of the book was outlined by the author in a paper presented to this Association at its convention in 1905, and is printed in the Journal for December, 1905, page 395.

Quite as important, in many ways, as the financial record of such a company, are the " house-to-house inspection," " on-and-off " and meter records, construction records, etc., which are illustrated in some detail.

The special accounts and records required by the other kinds of public-service works are explained and illustrated in the section devoted to those works. A commendable feature is the inclusion of the form of report required by the Massachusetts Board of Gas and Electric Light Commissioners.

The difficult but very important subject of depreciation is discussed briefly. Tables of annuities, compound interest, and sinking funds are also given.

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1906.

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◆

The Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only twenty-seven, its growth has prospered until now it includes the names of over 650 men. Its membership is divided into two principal classes, viz.: Members and Associates. Members are divided into two classes, viz.: Resident and Non-Resident, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The Initiation fee for the former class is five dollars; for the latter three dollars. The annual dues for both classes of Active membership are three dollars. Associate membership is open to firms or agents of firms engaged in dealing in water works supplies. The initiation fee for Associate membership is ten dollars, and the annual dues fifteen dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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